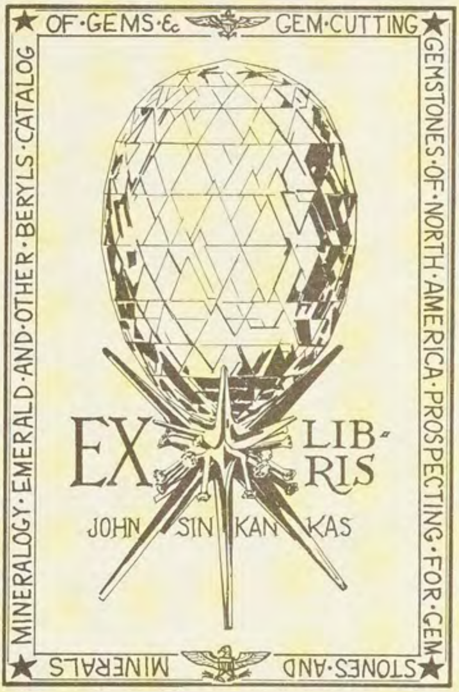
PRECIOUS STONES

BY

SIR A. H. CHURCH, K.C.V.O. F.R.S.

VICTORIA AND ALBERT MUSEUM
HANDBOOKS.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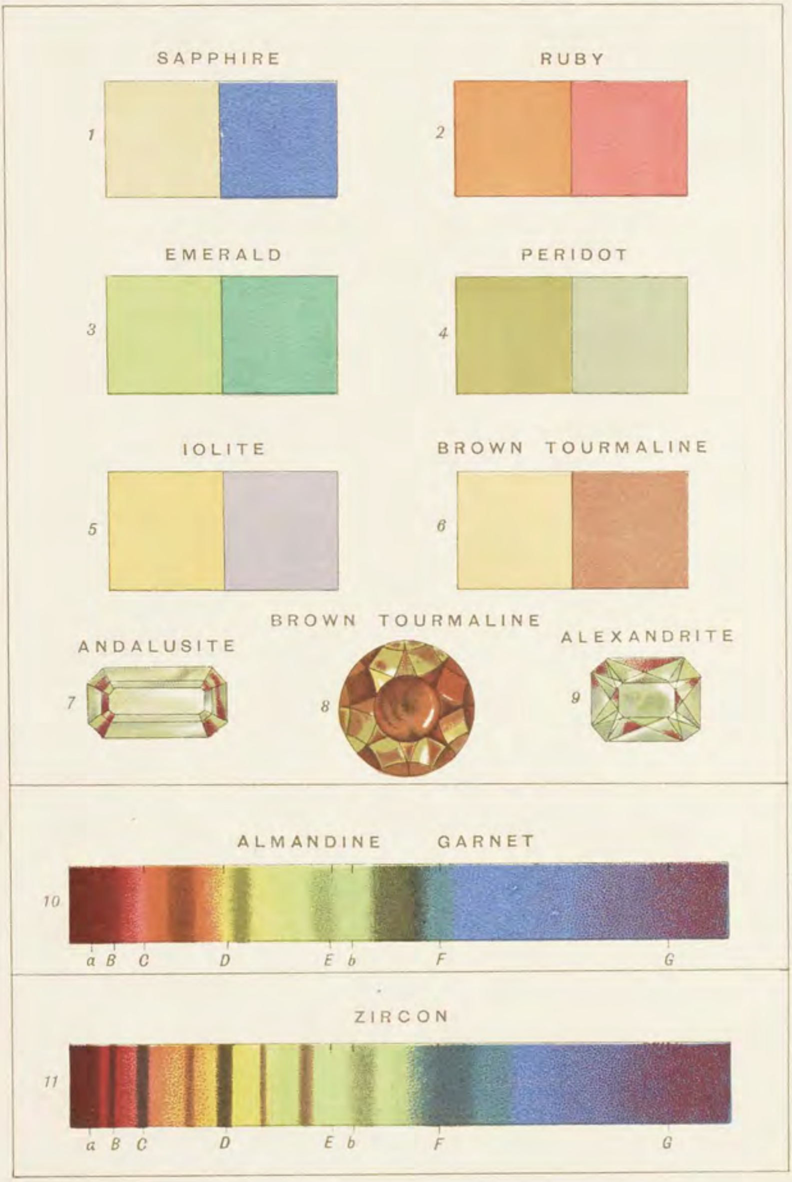

VICTORIA AND ALBERT MUSEUM.

PRECIOUS STONES

CONSIDERED IN THEIR SCIENTIFIC AND ARTISTIC RELATIONS.

A GUIDE TO THE TOWNSHEND COLLECTION.

BY

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PRECIOUS STONES.

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NOTE.

With a view to making this Handbook more suitable for use as a guide to the Townshend Collection of Precious Stones, two changes of arrangement have been made in the present edition.

(1) *The general account of the Collection, which was formerly printed at the end of the volume, has been placed at the beginning as an Introduction; and*

(2) *The catalogue of the Collection, which was also placed at the end of the volume in previous editions, has been broken up into sections, each section relating to one class of stone, and has been attached to the paragraphs which deal with the general features of the class.*

Sir Arthur Church has kindly revised the whole work, and has generously presented to the Museum certain valuable stones as the nucleus of a series which, it is hoped, may be formed to supplement the Townshend Collection and make it more completely representative. Among the additions (a full description of which is given in the Appendix facing page 158), *are specimens of Demantoid, Spodumene and Sphene. They are exhibited in the case containing the main collection.*

CECIL SMITH.

VICTORIA AND ALBERT MUSEUM,
July 1913.

PREFACE

(To the Second Edition).

Since 1882, *when the "Handbook of Precious Stones" was published, the volume has been several times reprinted from stereotype plates. Occasionally a few alterations and corrections were made in the text, but no opportunity occurred to improve the arrangement of the work or to add fresh material. The present issue, however, represents a thoroughly revised edition. A large number of paragraphs have been wholly rewritten, while so many additions have been made to the accounts given of the different kinds of precious stones and other beautiful minerals that the* 112 *pages of the original handbook have been increased to* 137. *Among the minerals which have now received fuller treatment may be named—diamond, sapphire and ruby, and the different varieties of garnet and of zircon. But readers who desire to make themselves more intimately acquainted with the optical properties, the crystal-forms and intimate structure, the modes of occurrence and formation and the chemical composition and constitution of precious stones, will find it necessary to turn to works in which full details of these subjects are given. In this connection may be named the treatises of Dana, of Professor Lewis of Cambridge, Professor Maskelyne and Professor Miers, for in the pages of the present handbook only such scientific considerations find place as can be easily grasped, and which, at the same time, help to explain the beauty of precious stones and afford methods of identifying the different kinds.*

The chief localities where precious stones are found have been named in Chapter VII. under the headings of the several species and varieties. But this subject cannot be adequately discussed without having recourse

to maps, both geographical and geological, to which no space could be allotted in an elementary handbook. But there is one rich district which seems to require special notice here in order to remove what seems to be a prevalent misconception. In the body of the present handbook frequent references are made to the occurrence of many gem-stones in Ceylon. The search for these beautiful minerals and the traffic in them has, in fact, been going on in that island for ages, while the plumbago and mica industries are affairs of to-day. Yet it is strange that the importance of the Ceylon trade in precious stones remains unrecognised not only in newspaper correspondence but in official documents and in standard books. One meets with such a statement as this—"Plumbago is, practically, our only mineral export"; and this, "The yield of gems in this island is not large, the total value of the annual production being said to be no more than £10,000." A glance at the true figures suffices to demonstrate the incorrectness of such statements. The value of plumbago exported from Ceylon in 1903 amounted to £119,316. Now the value of the gems exported in an average recent year by a single Colombo merchant was £30,000, while there are a score of other Ceylon gem merchants who together export no less than £200,000 worth annually. With casual sales to visitors to the island and to travelling dealers, a moderate estimate of the annual export of gems from Ceylon will be £300,000. The variety of kinds found is large, sapphires, spinels, alexandrites, chrysoberyls, beryls, topazes, catseyes, tourmalines, zircons, garnets and moonstones being the chief: diamonds, emeralds and turquoises do not occur, while pearls belong to a different category, being organic products. But it must be allowed that the precious-stone industry constitutes now, as it has done for many centuries, an important feature in the resources of the island.

In concluding these prefatory notes I have much pleasure in acknowledging the help of Dr. C. A. MacMunn, to whose skill in spectroscopy many scientists are largely indebted. He drew for me the absorption-spectra of almandine and of zircon, reproduced in the

coloured frontispiece. Although more exact in details, these drawings do not, I am glad to say, present any obvious differences from the corresponding figures in the plate issued in 1882 *with the first edition of this handbook. But they do show a marked superiority over the spectra figured in subsequent issues. The nine upper figures in the Frontispiece show the twin colours of certain precious stones, figs.* 1 *to* 6 *representing the hues as seen in the dichroiscope.*

A. H. C.

KEW GARDENS, *February* 1905.

PREFACE

(To the First Edition).

A revised Catalogue of the Townshend Collection of Precious Stones in the South Kensington Museum originated this Handbook, in which an attempt has been made to associate, if not to combine, the scientific with the artistic study of precious stones. It has been necessary to confine this work within somewhat narrow limits, and hence to omit much which might fairly find a place in a comprehensive treatise on the subject. The writer, however, trusts that what is here offered for the consideration of students and amateurs may increase the intelligent appreciation of precious stones, and further their more judicious treatment in jewellery. Notwithstanding the exquisite skill of a few modern artist-workmen, it must be affirmed that there is room for improvement in the ordinary production of jewellers' shops, with respect to knowledge, taste, and finish. Chiefly in fault, however, are the purchasing public, who still tolerate the horseshoes, anchors, and clumsy cables of a debased time, and are not quick to appreciate refinement and originality in the selection and artistic mounting of precious stones. So a few words about these beautiful materials—their nature, variety, and employment—may prove of wider service than a mere descriptive catalogue of the specimens belonging to the South Kensington Museum.

A. H. C.

Kew, *Nov.*, 1882.

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ILLUSTRATIONS.

BIBLIOGRAPHICAL NOTES.

The following books and papers on precious stones and on related topics may be consulted, especially for such technological, historical, and archæological details as do not fall within the scope of the present work.

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INTRODUCTION.

THE TOWNSHEND COLLECTION OF PRECIOUS STONES.

In the year 1869 the South Kensington (now the Victoria and Albert) Museum became possessed of a valuable collection of precious stones, under the provisions of the will (dated 6 August, 1863) of the Rev. Chauncy Hare Townshend. The following extract from the will refers to this bequest:

I, Chauncy Hare Townshend, late of Down Hill, in the parish of Tottenham High Cross, in the county of Middlesex, and now of Norfolk Street, Park Lane, in the parish of St. George, Hanover Square, in the said county, Clerk, do hereby revoke all Wills and other Testamentary Dispositions heretofore made by me, and declare this to be my last Will and Testament. I appoint my friends Burdett Coutts of Stratton Street, Piccadilly, in the said county of Middlesex, spinster, and the Reverend Thomas Helmore, Master of Her Majesty's Choir at the Chapel Royal, St. James's, trustees and executors of this my Will. I give and bequeath to the Right Honourable Granville George Leveson Gower, Earl Granville, or other the President of Her Majesty's Council on Education for the time being charged with the promotion of Art Education, now undertaken by the Department of Science and Art, such of my pictures and water-colour drawings and engravings and books containing engravings as his Lordship or other the President aforesaid may think fit to select; and my collection of Swiss coins and my box of precious stones (including such as are generally kept therein but which in my absence from England may be with me on the Continent); and my box of cameos (which boxes, for the sake of identity, I declare to be those which in my absence from England are always deposited for safe custody with my bankers); and the ancient gold watch formerly belonging to my father, which, being stolen

by the celebrated Barrington, was the cause of his transportation, together with the chain, seal, and keys thereunto attached; and also the looking-glass and frame over the dining room chimney-piece, which frame was carved by Grinling Gibbons; on condition that the said several articles be never sold or exchanged, but to the intent that the same may be deposited and kept in the South Kensington Museum, or any other suitable place which may be provided in substitution for that Museum, and exhibited to the public, with the other Works of Art which now are or may be therein.

The Townshend collection of precious stones contains 154 specimens, nearly all of them mounted in gold, as rings. A considerable number of these specimens once formed part of the famous "Hope collection," and appear in the "Catalogue of the Collection of Pearls and Precious Stones formed by H. P. Hope," described by B. Hertz, 1839. Two copies of this catalogue are in the Library, Victoria and Albert Museum. One of these copies contains MS. additions, and belonged to Mr. H. Hope and then to Mr. Townshend: in it are entries giving the prices paid for many of the specimens. Many of the specimens are figured in Hertz's "Catalogue"; fifty of these illustrations, representing stones now in the Victoria and Albert Museum, have been reproduced for the present volume. Mr. Townshend's bequest to the Museum included, besides the above precious stones, 41 other specimens (Nos. 1791—'69 to 1831—'69). These are engraved gems, some antique and some modern, chiefly in onyx, cornelian, and sard. One example, however, is on turquoise, and is remarkable for its size; it is an irregular octagon, 2 inches long by rather more than 1½ inch broad.

A catalogue of the Townshend gems was written by the late Professor Tennant, and published by the Science

and Art Department in 1870. The author of the present Handbook of Precious Stones has submitted each specimen to such an examination as could be managed with cut and mounted stones, and has been enabled to correct some of the attributions. These corrections were first made by him in "The Spectator" of July 9th, 1870; they were reproduced in "The Quarterly Journal of Science" for January, 1871, and were adopted by Mr. Hodder M. Westropp in his "Manual of Precious Stones," published in 1874.

No strictly scientific classification of precious stones is possible. Those in the Townshend collection have been described in the same order as that adopted in chapter vii. It so happens that the diamond, as consisting of the pure element *carbon*, takes for every reason the first place; while the sapphire and ruby, as varieties of corundum, the oxide of aluminium, naturally fall into the second position. Other species are grouped roughly in accordance with some prominent constituent:

Characteristic element.		
CARBON	..	Diamond.
ALUMINIUM	..	Corundum, spinel, turquoise, topaz, tourmaline, garnet.
MAGNESIUM	..	Peridot.
GLUCINUM	..	Beryl, chrysoberyl, phenakite, euclase.
ZIRCONIUM	..	Zircon.
SILICON	..	Opal, quartz, iolite, moonstone.

There are, as might have been expected, some stones unrepresented in the Townshend collection. Amongst these may be named—Alexandrite, Axinite, green garnet or Demantoid, Spessartite, Odontolite, Phenakite, Spodumene, and Sphene. Anyone interested in precious stones should, after inspecting the Townshend collection, turn to the general collection of rings in the museum. The

beautifully and curiously cut diamond in a ring found at Petersham (No. 780—1904); the two Indian thumb-rings of white jade (1022 and 1023—1871); the Persian turquoise with gold-inlays (965—1871); and the two fine bloodstones (735 and 749—1871), are specially noticeable.

PRECIOUS STONES

CONSIDERED IN THEIR SCIENTIFIC AND ARTISTIC RELATIONS.

CHAPTER I.

DEFINITION OF PRECIOUS STONES.

BEAUTY, durability, and rarity—such are the qualities characterising the minerals to which we apply the adjective "precious." But the term "mineral," though including all true precious stones, does not exclude some natural products of the earth (such as gold and platinum) which, though precious, are not *stones* in the ordinary acceptation of that word. Native metals, then, are outside the category of precious stones. On the other hand, at least one animal product, the pearl, is commonly ranked with such minerals as the diamond and the sapphire, associated as it is with these stones in jewellery, and partaking as it does of the characters of beauty and rarity, with a good share of durability.

After all, it is no easy matter to define a precious stone. Where can the line be drawn between stones that are precious and stones that do not merit that appellation? Is not the preciousness of one sort of stone or of another dependent in part upon caprice, upon time

and place? If the fashion follow some new direction, then gem-stones now reckoned of small value might in some measure displace the diamond and the ruby; for, compared with these gems, there are doubtless several hard and beautiful stones which are found in less abundance, but which remain less costly because in less demand. Yet there is something to be said in favour of the high position commonly given to the diamond, the ruby, the emerald, the sapphire, and we may add the pearl and the opal: they all possess a very conspicuous and obvious beauty. By brilliancy and colour they force themselves upon our attention, while the spinel, the jargoon, and the tourmaline generally need to be studied, to be looked into, that their merits may be discovered. But the argument that beautiful stones ought not to be employed in the higher kinds of bijouterie unless they are costly is an unworthy one. It will not bear criticism. Why should not moonstones, even if they can be bought for a shilling apiece, be introduced into goldsmiths' work of the most artistic sort? Surely they may rank at least with coloured enamels, which are of extremely small money value, but which are prized highly when employed with skill in well-designed jewels.

It has been before stated that the caprice of fashion influences and alters the market value of precious stones from time to time. The peridot, the amethyst, the cat's-eye, and the aquamarine have each had their day, and then been abandoned for new favourites. Even the emerald has suffered vicissitudes, and so has the opal. The causes of such changes in the popular esteem in which particular species of gems are held cannot often be traced. A new fashion is set or an old one restored, and

once set is blindly followed. The introduction of a little-known gem, however beautiful it may be, is generally a most difficult matter. A jeweller who was in the first rank of artistic workers was showing a customer a bracelet beautifully set with the rich green garnets of Bobrovka. This lady admired the stones and the workmanship immensely, but spoke of the former as *emeralds*. The jeweller honestly said: "They are not emeralds, but a rare sort of garnet from the Ural Mountains." Forthwith the lady rejoined: "Well, after all, I do not think I care so very, very much for this bracelet; please show me something else." Not that she knew that there did exist a real objection to these green garnets—they are not quite hard enough to stand much wear. For the ignorance that prevails about precious stones, not only among the wearers and owners of them, but also among jewellers themselves, is indeed dense. A London goldsmith had six stones to mount as rings; in returning them finished, the invoice gave to the specimens five wrong designations! A few years ago how very few jewellers understood what was wanted when a tourmaline or a jargoon was asked for! and yet the tourmaline and the jargoon have been long known. Diamond, ruby, emerald, sapphire, pearl, opal, turquoise; turquoise, opal, pearl, sapphire, emerald, ruby, diamond—such is the range and variety of acknowledged gems. If a novelty has to be introduced it must be called by some modification of these well-known names, and must become a "Cape ruby" or an "Uralian emerald." In speaking further on, in reference to the artistic use of precious stones, something more will be said upon this point of the neglect of certain kinds of extremely beautiful stones.

From the statements just made it will be gathered that although a stone to be precious must have, in very good measure, the qualities of beauty, durability, and rarity, yet we cannot arrange precious stones in any fixed and definite order, by assigning them places in our list in accordance with the degrees in which they possess these three qualities. Even if all stones going under the same name were equally fine this would be impossible; much more is this the case when we learn that two specimens—say of ruby—each weighing the same, might be worth five pounds and fifty pounds respectively. In placing these three necessary qualities of beauty, durability, and rarity in this sequence, the intention has been to express the pre-eminent necessity for beauty in stones deserving the name of precious; the importance of durability, which must claim the second place; and the desirability of a certain degree of rarity, especially where the quality of durability may not exist in the highest degree. How far a very beautiful and hard mineral would maintain its position as a precious stone in the event of its becoming exceedingly abundant, one cannot venture to judge; but as we have to deal with existing facts only, the problem is one which practically has not yet been presented for solution.

As precious stones have just to be looked at and worn, or used in decorative work, it will be readily understood why no occult property is of much moment in determining their value. Individual and learned amateurs may indeed value a stone according to what they know of its history, its romance, its memories, or the curiousness of its components; but in ninety-nine cases in a hundred any enhancement of value through such causes is out of the

question. Still, from the mineralogical and chemical points of view, it is perhaps legitimate to import some elements of interest when appraising the right of a stone to be called precious, or its place in the list of gems. One need not follow those writers who speak of precious, semi-precious, and common stones; but one may reasonably arrange the different kinds in a few groups or classes, according to what we may call the average sum of their merits. To assign a precise place to each species is not possible. Hence the futility of such a classification as that published in 1860 by K. E. Kluge wherein emerald takes lower rank than zircon, and precious opal comes after garnet, while to turquoise is assigned a place beneath nine other stones only one of which (peridot) is even known to dealers in precious stones and to the purchasers of jewels.

CHAPTER II.

PROPERTIES AND DISCRIMINATION OF PRECIOUS STONES.

SUCH properties of precious stones as are perceptible to the eye unaided by optical apparatus, but trained to keenness of vision, afford valuable means of discriminating precious stones from one another, but do not exhaust such means. Indeed, such mechanical properties as hardness and specific gravity are of the greatest use in determining the species of a stone, and are more commonly available than the majority of optical tests. Optical properties must, however, ever hold a chief place in all artistic classifications of precious stones, so that it will not be unadvisable to begin the present chapter by a synopsis of the most obvious characters of this class. They may be arranged in the form of a tabular view, the use of which is twofold, enabling us to define the several optical properties found in gem-stones, and also to appreciate their artistic capabilities. We arrange these optical (or mainly optical) qualities under the general heads of "Surface" and "Substance":

SURFACE.	*Form* . . .	1. Plane.
		2. Curved.
	Lustre . . .	3. Metallic.
		4. Adamantine.
		5. Resinous.
		6. Vitreous.
		7. Waxy.
		8. Pearly.
		9. Silky.

SUBSTANCE.	*Light* . . .	10.	Transparent.
		11.	Translucent.
		12.	Opalescent.
		13.	Chatoyant.
		14.	Opaque.
	Colour . . .	15.	Iridescent.
		16.	Monochroic.
		17.	Pleochroic.
		18.	Fluorescent.

The greater number of these terms will be found illustrated in the present and succeeding chapters: we now proceed to the discussion of the qualities which underlie them, and of other important physical characters of precious stones. The order which will be followed may be gathered from this scheme:

REFRACTION.	HARDNESS.
DISPERSION.	SPECIFIC GRAVITY.
POLARIZATION.	FORM.
PLEOCHROISM.	STRUCTURE.

Refraction of Light.—The familiar experiment of plunging a stick in a vessel of water and observing the broken appearance which it assumes, serves to illustrate the action called "refraction," or bending back. This refraction of light occurs in the majority of cases where a ray of light falls upon one transparent medium from another—say from the air upon a diamond. Part of the incident light enters the diamond, and follows a different path—is refracted. The diamond, like liquids, glass, and other molten or vitreous—that is non-crystalline—matter, possesses the property of simple refraction; many precious stones, indeed the majority, are doubly refractive. A

bright spot of light, say a small candle-flame, when viewed through a single refracting stone appears single; through a doubly refracting stone, double. The stone should be moved from the eye until, even when at a considerable distance, the flame seen through it appears single or double, as the case may be. All crystals belonging to the cubical system, such as diamond, spinel, and garnet, are, like glass and strass, simply refracting; ruby, beryl, topaz, and quartz are all doubly refracting. There are very precise and beautiful methods for ascertaining this quality in transparent crystals, but all are not applicable generally to cut and polished gem-stones. The results of some of these accurate measurements of the indices of refraction of transparent minerals will be found in chapter vii.; that they differ much in different species may be seen from this brief list of indices for the yellow ray:—

Diamond	2·417	Spodumene	1·674
Zircon	1·98	Phenakite	1·667
Spessartite	1·798	Tourmaline	1·643
Almandine	1·79	Heavy flint glass	1·619
Ruby	1·77	Beryl	1·585
Pyrope	1·755	Rock crystal	1·553
Chrysoberyl	1·753	Iolite	1·551
Spinel	1·726	Crown glass	1·524
Peridot	1·697	Water	1·336

Although this series of refractive indices may be accepted as containing numbers near the truth, it must be remarked that every doubly-refracting substance has two indices of refraction for each ray, although the difference between these indices rarely exceeds five units in the second decimal place, and generally amounts to less than one unit.* And it should be mentioned that the same species of stone, even in its

* The greater refractive index is that quoted in the table.

apparently purest condition, does not present, in all specimens, precisely the same optical features; there are differences due in part to chemical, in part to molecular causes. Thus there have been observed in fine diamonds variations of refractive index amounting to several units in the second decimal place, while, in the case of zircon, specimens of the different varieties have furnished, for the ordinary refractive index with yellow light, figures ranging between 1·95 and 1·84; that is a difference of 0·11. The unit to which all these indices are referred is that of air, which is taken as 1·0. In connection with the refraction of light by precious stones mention should be made of the phenomenon of total internal reflection. This, so conspicuous in the case of diamond and other gems of high refrangibility, fills the stone with light, and contributes very largely to the beauty of its appearance. This subject is fully discussed in Part I. of the volume on Precious Stones by Dr. Max Bauer and Mr. L. J. Spencer.

In the year 1905 Dr. G. F. Herbert Smith, of the Mineral Department of the British Museum, introduced a form of refractometer easy to manipulate and of portable size. Two years later the inventor gave us a still more convenient and efficient instrument capable of dealing with all stones having a refractive index under 1·775, and, moreover, possessing a scale the readings of which furnish, without calculation, the direct refractive indices for sodium light. This second and improved model of the Herbert Smith Refractometer, which is made by Mr. J. H. Steward, of 457, West Strand, London, is used in the following way. A drop of methylene iodide is placed on the plane surface of the dense glass of the instrument; then a flat polished facet of the cut stone to be tested is held

accurately in position, so that an even film of the liquid intervenes between that facet and the glass. The instrument is now maintained in such a position that light enters it through the lenticular opening on the under side; a convenient source of illumination is the diffused light reflected from a sheet of white cardboard or a slab of plaster of Paris. If the proper angle be secured, and the upper part of the instrument be screened from light that might enter from above, the higher part of the field will be dark, ending in a bluish edge due to the stone under examination. Near the bottom of the field of view will be seen another and less-coloured edge due to the methylene iodide. Should methylene iodide, saturated with sulphur to increase its refractivity, be employed, this second edge will lie outside the range of the instrument. The reading of the refractive index is taken at that part of the edge (due to the stone) where the green passes into the yellow, and meets the right-hand side of the scale, that is the centre of the field. More accurate results may be obtained by the use of the monochromatic light of a sodium-flame. Fuller directions as to the use of this refractometer, with details as to its range, its accuracy, and the results obtained by its means, will be found in an illustrated pamphlet written by Dr. Herbert Smith and published by the maker of this beautiful little instrument.

Dispersion of Light.—When a ray of light passing from one medium to another is bent or refracted, the light being composite and consisting of rays having different degrees of refrangibility, it suffers dispersion as well as refraction. In this way the several component rays, differently coloured, are separated more or less widely from each other, and are said to be *dispersed*. Upon this

property of gems depends that peculiar quality of "fire" —the play of prismatic hues, which is the most marked characteristic of the diamond. It is the difference between the extreme indices of refraction of the red ray and of the violet ray (the B and G lines) at the ends of the visible spectrum. It is best measured by taking as standards those fixed lines in the solar spectrum; for the purpose of comparing the dispersive powers of different stones, the following list of dispersion-coefficients, derived chiefly from determinations made by Dr. Herbert Smith, will perhaps suffice:

Green Garnet	·057	Peridot	·020
Sphene	·051	White Sapphire	·018
Borosilicate of lead	·049	Spodumene	·017
Diamond	·044	Tourmaline	·017
Zircon	·038	Crown glass	·016
Flint glass	·036	Chrysoberyl	·015
Hessonite	·028	Beryl	·014
Pyrope	·027	Topaz	·014
Almandine	·024	Rock crystal	·013
Spinel	·020	Moonstone	·012

Polarization of Light.—There are several ways in which light may suffer the remarkable change known as polarization. If we assume that a beam of ordinary or natural light, freely traversing any medium, has what we may call *identical properties on all its sides*, then, should that beam encounter any obstacle, as by reflection or refraction, it exhibits to a greater or less extent different properties on different sides—is, in fact, polarized. One quality of this polarized light is that it cannot be again reflected at a certain angle, nor can it again traverse in a certain direction the crystal in which it has suffered this change. But the amateur of precious stones is mainly concerned with these two facts, that in some

doubly-refracting crystalline minerals the two oppositely polarized beams are of different colours; and, secondly, that some transparent gem-stones are more or less opaque, in one direction at least, to one of the two oppositely polarized beams. Thus it will be clear that upon double refraction and its concomitant polarization depends that property of many gems which is known as pleochroism, and which may be most easily recognized by that useful little instrument, the dichroiscope.

Pleochroism.—When a distinctly coloured precious stone is examined by means of a dichroiscope it will invariably show two images of the same hue or of different hues. Should the two images of the square opening of the instrument be identical in colour, then the specimen may be a garnet, a spinel, or a diamond; it cannot be a ruby, a topaz, or a beryl, all of which show twin colours differing in a perfectly recognizable degree from each other. However, before proceeding with the description of the special applications of the dichroiscope, a word on the construction of the instrument may be introduced. It consists of a cleavage rhombohedron of Iceland spar, having its longer edges nearly an inch long and its shorter edges about three lengths of an inch each. In the original form of the instrument a small glass prism of 18° was cemented on each of the small end faces of the prism; but this may be done away with if these end faces be ground and polished so as to be perpendicular to the length of the prism. A sliding cap at one end has a square perforation of about ·12 inch; at the other end is a lens, or combination of lenses, of such focal length as to show a distinct image of the square opening when the cap is pulled out a quarter of an inch or so.

With an instrument so constructed the pleochroism of the vast majority of gem-stones may be determined at a glance. Of course, this quality is so conspicuous in some species (tourmaline and iolite) that no instrument is usually needed to discern it. For it is easy to notice that the colours of some crystals, seen by transmitted light, vary with the direction in which they are viewed. If the transmitted ray be analysed by a Nicol's prism, its colour will be found to vary as the prism is turned round its axis; in fact, the two differently coloured beams are polarized in opposite planes. It is, of course, only in doubly-refracting crystals that this phenomenon of dichroism occurs. In the descriptions given further on, of the several species of stone, these twin colours, as seen by the dichroiscope, are duly recorded. Here, however, it may be useful to group a few conspicuous instances of dichroism together; several are illustrated by Figs. 1 to 9 of the Frontispiece.

NAME OF STONE.	TWIN COLOURS.	
Sapphire (blue)	Greenish straw	Blue.
Ruby (red)	Aurora red	Carmine red.
Tourmaline (red)	Salmon	Rose pink.
,, (brownish red)	Umber brown	Columbine red.
,, (brown)	Orange brown	Greenish yellow.
,, (green)	Pistachio green	Bluish green.
,, (blue)	Greenish grey	Indigo blue.
Emerald (green)	Yellowish green	Bluish green.
Topaz (sherry)	Straw yellow	Rose pink.
Peridot (pistachio)	Brown yellow	Sea green.
Aquamarine (sea green)	Straw white	Grey blue.
Beryl (pale blue)	Sea green	Azure.
Chrysoberyl (yellow)	Golden brown	Greenish yellow.
Iolite (lavender)	Pale buff	Indigo blue.
Amethyst (purple)	Reddish purple	Bluish purple.

When examining a stone for dichroism, it is necessary that the specimen should be looked through in some direction other than that (along a certain optic axis) in which the crystal is only singly refracting. Trials in different positions, for the optimum effect, having been made, the stone should be fixed in such a way that it can be placed close to the square opening of the dichroiscope. A disc of millboard having a hole in the middle may be used as a holder, the specimen being fixed in position by means of a little blackened beeswax. Then the two images of the square opening of the dichroiscope should be focussed sharply by means of the sliding cap. It will be observed that one image of the opening is nearly central; this represents the ordinary ray, for which, in the present volume, the symbol ω is employed. The other image, formed by the extraordinary ray and expressed by the symbol ϵ, is more displaced, and is distinguished by a narrow blue border on its outer edge, and by a narrow red border on its inner edge. On turning the instrument round, the greatest differences of hue between the two images furnished by a dichroic stone will be seen four times during a single rotation; four times the two squares will be identical in colour. These phenomena correspond to eight positions, all 45 degrees apart in the circle of 360 degrees. With coloured glasses and all other singly-refracting substances the images are alike in all positions.

Further discussion of the optical properties of precious stones, including the colour-effects produced by *diffraction*, *absorption*, and *interference*, would be out of place in a handbook of elementary character. For detailed description of the phenomena in question, reference may be

made to any treatise on experimental optics; for a brief account the author's little book on "Colour" (Cassell & Co.) may be consulted.

Hardness.—One of the characters by which gem-stones may be distinguished from each other and from their imitations is that of the degree in which they possess the power of resisting abrasion. Many hard minerals may, however, be easily broken, fractured or chipped, though they cannot be scratched: a very hard stone may be a very fragile one. Emeralds, zircons, and diamonds have often been ruined by a fall or a blow.

The scale of hardness adopted for minerals was devised by Mohs. Fragments of transparent minerals, which may be conveniently mounted in handles, are applied in succession to the stone under examination, so as to attempt to scratch its surface. When the stone neither scratches nor is scratched by any member of the scale, the hardness of the two stones is the same. When it scratches the softer, and is scratched by the harder of the two test-stones, some notion of its position between them may be gained by passing all three specimens, with slight pressure, over the surface of a fine, clean, hard file, one end of which rests upon the table, and noting their different degrees of resistance to abrasion and the sounds produced. In chapter vii. of this book will be found, under the description of each kind of precious stone, numbers which nearly represent the average hardness of good specimens of the several sorts according to the common mineralogical scale, which is—

Diamond	10	Apatite	5
Sapphire	9	Fluorspar	4
Topaz	8	Calcite	3
Quartz	7	Rock salt or Gypsum ..	2
Felspar	6	Talc	1

A list of the degrees of hardness of a considerable number of different gem-stones will serve to show their relative positions with regard to this scale. Although this character of hardness cannot be extensively used in the discrimination of cut and polished gem-stones, yet it is sometimes available even in the case of such specimens when unmounted, the "girdle" of the stone offering a suitable surface for a trial of hardness.

As the property of hardness is of great value in the case of precious stones, those kinds which are scratched by quartz, and which, consequently, are below 7 degrees of hardness, are ranked as half-hard, or "demi-dures." Stones scratched by a knife are below 5 degrees.

TABLE OF HARDNESS.

Diamond	10·0	Jadeite	7·0
Sapphire and Ruby	9·0	Amethyst	7·0
Chrysoberyl	8·5	Spodumene	6·5
Spinel	8·0	Benitoite	6·5
Topaz	8·0	Peridot	6·5
Aquamarine	7·8	Moonstone	6·3
Emerald	7·6	Jade	6·2
Zircon	7·5	Green garnet	6·0
Tourmaline	7·5	Turquoise	6·0
Phenakite	7·5	Opal	6·0
Andalusite	7·5	Enstatite	5·5
Almandine	7·5	Beryllonite	5·5
Iolite	7·3	Sphene	5·5
Cinnamon stone	7·0	Lapis-lazuli	5·2

There are two remarks as to degrees of hardness which it is proper to introduce in this place. Firstly, the degree of hardness of a crystal or a cut stone varies, generally, however, within narrow limits, on different faces and in different directions. Secondly, the usually accepted scale of hardness is one having very different values for the different intervals. Unlike the degrees of the thermometer, where the interval between one degree and the next above

it or below it has the same value, whatever part of the scale be chosen for comparison, the degrees of hardness on Mohs' scale show extraordinary divergences.

Specific Gravity.—The most generally applicable of all modes of discriminating precious stones from one another is to ascertain their specific gravity—that is the relative weights of equal bulks, the weight of a bulk or volume of distilled water (commonly taken at 60° F. or 15·6 C.) being employed as the unit with which all the others are compared. There are three modes of ascertaining the specific gravity of a stone: (1) By placing it in heavy liquids of known specific gravity, and noting the position which it takes up. (2) By weighing it in air, and then in water (or other liquid), and thus learning the weight of water which the stone displaces—that is the weight of an equal bulk of water. (3) By measuring or weighing, directly or by difference, the water which the stone displaces when immersed in water in a small vessel of known capacity. We will now briefly describe these three methods.

1. Several different liquids have been used for the purpose of ascertaining the density of minerals, and even for separating species having different densities from one another. One of these liquids, which has done good service in its day, is a saturated solution of potassio-mercuric iodide. This may be prepared so as to have a density of 3·18 at 15° C. It is a yellow liquid called after its discoverer Sonstadt's Solution. Unfortunately this liquid is very poisonous and rapidly destroys, by amalgamating the metal, any brass apparatus with which it may come into contact. Two substitutes for this liquid are now in use. One is an aqueous solution, which may be diluted at will with water, of the compound known as

cadmium boro-tungstate. The crystals of this salt, to which the formula $Cd_2 W_9 B_2 O_{32}$, $2 H_2O$ + 16aq. has been assigned, when fused, over a water-bath in their own water of crystallization, yield a liquid which at 75° C. has the specific gravity 3·55. At 22° C. this cadmium tungstoborate in crystals requires but 1-10th of its weight of water for solution: a very small further addition of water enables one to secure a solution which at 15° C. presents the specific gravity of 3·28. The other heavy liquid to which reference has been made, as a second substitute for Sonstadt's Solution, is methylene iodide, the formula of which is $CH_2 I_2$. This compound has the density of 3·32 at 15° C. Its density may be lowered by the addition of toluene, which, at the same temperature, has the density of 0·869. On the other hand, the density of methylene iodide may be raised by saturating it with iodoform ($C H I_3$) and iodine. It is well to be content with the addition of iodoform only, for iodine makes the liquid too dark in colour for the movements of a stone put therein to be observed. It will be seen that we have now at our disposal liquids which present a range of density sufficiently wide to permit of the identification of minerals having densities up to about 3·4: and this result can be achieved without having recourse to those liquids which need to be warmed above 15° C. in order to maintain them in a liquid condition. It ought to be mentioned that the methylene iodide preparations, owing to their volatility and to their high coefficient of expansion when heated, yield results, which, in the absence of the necessary precautions, may easily be somewhat inexact.

In order to furnish a liquid which will enable one to deal with stones having a density above 3·4, the double

nitrate of thallium and silver may be taken. It is better to purchase this salt ready prepared, but it may be made by melting together 150 grams of crystals of commercial thallium nitrate and 64 grams of silver nitrate along with a little water and heating the mixture with constant stirring until the temperature of 70° C. has been reached. It is possible thus to obtain a liquid which at 75° C. has a density of 4·8, but in practice this figure need not be reached. It must be remembered that all the dilutions of this liquid have one common property—they are poisonous; moreover they stain the skin a dark slaty purple not easy to remove.

For the purpose of the collector and connoisseur in precious stones it will suffice to have at hand the following six heavy liquids:

A. Thallium and silver nitrate solution of specific gravity 4·5 maintained at a temperature well above its fusing point.

B. Thallium and silver nitrate solution of specific gravity 4·1 maintained at a temperature well above its fusing point.

C. Thallium and silver nitrate solution of specific gravity 3·9.

D. Thallium and silver nitrate solution of specific gravity 3·5.

E. Cadmium boro-tungstate solution of specific gravity 3·28 at 15° C., or methylene iodide slightly diluted with toluene.

F. Cadmium boro-tungstate solution of specific gravity 2·67; this is prepared by diluting *E* with water until a fragment of beryl sinks and a fragment of amethyst floats therein. Or methylene iodide, diluted with toluol to the same density and with the same indicators, may be substituted.

The stone to be determined should be first placed in liquid A, in which all stones but red, dull-green, puce, yellow, white, and brown zircons will float. After removal from A, washing with hot water and wiping dry with a cloth, the stone (which has not sunk in A) is placed in liquid B, where, if it sinks, it may be almandine,

spessartite or golden-zircon. Should it not sink, it is transferred with due precautions to C. Here, if it sinks, it may be ruby, sapphire, or one of the other varieties of corundum, or possibly a green zircon. If, however, the stone floats in C it may belong to one of the much larger groups, with which we will now endeavour to deal in a tabular form :—

In solution D		In solution E	
Diamond Topaz Spinel Chrysoberyl Alexandrite Pyrope Demantoid	sink	Jadeite Diopside Peridot Chrysolite	sink

In solution F			
Beryl Emerald Turquoise Phenakite Jade Tourmaline Spodumene	sink, while	Opal Moonstone Lapis-lazuli Iolite Amethyst	float

Much may be learnt by the behaviour of a stone in the liquid employed. It may sink or rise slowly when its specific gravity is near that of the liquid, or it may remain, as it were, suspended in the midst, in cases where its density is the same as that of the liquid. Before using any of the solutions their specific gravity should be carefully determined; they must be preserved from dust, evaporation, etc., in suitable stoppered and

capped bottles or short wide tubes in the case of A and B. A number of weighted glass bulbs or a series of small mineral fragments of ascertained specific gravity are very useful as "indicators." It is a good plan to keep one or more of these indicators in each liquid to be employed. To avoid doubt and confusion these indicators, whether bulbs or mineral fragments, should present so characteristic a form or colour or marking that their identity and value can be recognized at once. It is worth while adding the remark that liquids A, B, and C are required much less frequently than the less dense liquids, and that when the position of a doubtful stone has been once fixed by the density test so as to prove that it belongs to a particular group, then it may be necessary to call in the aid of the dichroiscope and of the scale of hardness in order to learn to what species in that group the stone really belongs.

2. By weighing a stone in air and then in some liquid of known density, the weight of the bulk of the latter displaced by the stone is ascertained. If, for example, a sapphire weighing 4 grains in air weighs but 3 grains in water, it has evidently displaced 1 grain of water, becoming lighter by that amount. So the number 4 represents the specific gravity of sapphire, showing as it does, the number of times that the weight of any bulk of that stone contains the weight of an equal bulk of water. An example of an actual experiment of this kind will serve to illustrate this, the ordinary method of taking specific gravities, better than any further explanation of the principle involved.

A yellow sapphire weighed in air . .	12·896	grams
,, ,, ,, water . .	9·677	,,
Difference, that is, weight of water displaced	3·219	,,

The proportion will be:

Wt. water displaced.	Sp. gr. water.	Wt. sapphire.	Sp. gr. sapphire.
3·219 :	1 =	12·896 :	x

$x = 4·006$.

There are several corrections which are needed before an exact result can be reached. They are these: Firstly, the stone and the water must be compared at the same temperature, usually that of 60° F. or 15·6 C. This is the most important correction and the only one usually applied; it is well to avoid the necessity of introducing it, by conducting the experiment at the standard temperature. The second correction originates in the fact that the stone is weighed in air, and consequently is buoyed up to some extent by that fluid, appearing lighter than it would be if weighed *in vacuo*. The third correction depends upon the material of the weights. These, if of brass, displace from one-half to one-third of the amount of air displaced by the stone in the other pan of the balance, and consequently involve another error. The several corrections we have named may be learned with sufficient accuracy by the following methods: The correction for temperature may be applied by multiplying the difference between the weight in air and the weight in water, not by unity, but by the actual specific gravity of water at the observed temperature,* then proceed with

* If the specific gravity of water at 4° C. be taken as 1, then the specific gravities at higher and lower temperatures will be:

0°	·99987	7°	·99993	14°	·99930
1	·99993	8	·99989	15	·99916
2	·99997	9	·99982	16	·99900
3	·99999	10	·99975	17	·99884
4	1·00000	11	·99966	18	·99865
5	·99999	12	·99955	19	·99846
6	·99997	13	·99943	20	·99826

the calculation as before. The correction on account of the air and the brass weights is given by the formula :

$$y = w \cdot 0012 \left(\frac{1}{d} - 0 \cdot 12\right)$$

where w is the observed weight in air of a given substance; d its approximate specific gravity; ·0012 the mean density of atmospheric air; ·12 the reciprocal of the specific gravity of brass; and y the weight by which the substance when weighed with brass weights will appear too light. The true weight, W, *in vacuo* will then be:

$$W = w + y$$

Now, with the true weight, W, *in vacuo*, the specific gravity may be calculated according to the equation previously given. To furnish a notion of the value of this correction, it may be stated that a fragment of rock crystal weighing 10 grams will become 10·0031 grams, a gain of 3 parts in 10,000.

When the specific gravity of a small gem is to be taken, an assay balance of great accuracy may be advantageously employed.* In this case the full advantage of the delicacy of the instrument cannot be secured if water, which has a high surface-tension, be the liquid in which the stone is weighed, the friction between it and the stone and immersed pan being too great. Alcohol considerably diluted with water answers well. A fair quantity is prepared and preserved in a well-stoppered and capped bottle. Its specific gravity is best ascertained by means of Dr. Sprengel's tube. In the following example of an experiment a dilute alcohol of sp. gr. ·8488 at 15° C.,

* M. Jolly's spring balance, as modified by Mr. C. F. Cross, is another useful form of instrument for this purpose.

and containing about 80 per cent. by weight of absolute alcohol, was used:

Specific gravity of brilliant-cut specimen of phenakite.

Weight in air . . .	1·1294 gram.
,, ,, alcohol at 15° C. .	0·8064 ,,
Alcohol displaced . . .	0·3230 ,,

The equation will be:

$$\frac{1 \cdot 1294 \times \cdot 8488}{\cdot 323} = 2 \cdot 9676 = \text{sp. gr. of phenakite.}$$

The one objection to this use of diluted alcohol consists in the tendency which it has to change its density by loss of alcohol; on this account pure toluene, a liquid hydrocarbon, having a density of ·869 at 15° C., affords a convenient substitute for spirit.

3. The third method of taking specific gravities does not admit of great exactness. A small wide-mouth bottle or beaker, with a ground rim and ground-glass cover, both truly plane, is filled with water, the cover placed in position, avoiding air-bubbles and wiping off any water outside the vessel, and then weighing it and its contents. Let this weight be x. Now introduce the gem and replace the lid as before; let the present weight be y, and that of the gem in air w; then approximately,

$$\frac{w}{w + x - y} = \text{sp. gr.}$$

In employing this method the vessel used should be no larger than will contain the specimen.

Specific gravities may be ascertained by means of contrivances dependent upon the measurement of the liquid

the objects displace from a vessel of known capacity or carefully graduated. The space at our disposal will not allow of any further details on this subject. But a caution as to the necessity in all specific gravity experiments of getting rid of air-bubbles may not be out of place. To attain this end boiled water should be used, and if mechanical contrivances fail (a feather or sable pencil) then the liquid and stone should be placed under the receiver of an air-pump and the air exhausted.

Details concerning the specific gravity of each kind of precious stone will be found in chapter vii. The following table gives a fair number of average densities arranged in regular sequence:

FOUR AND ABOVE		THREE AND ABOVE.		TWO AND ABOVE.	
Hæmatite ..	5·30	Green garnet ..	3·85	Phenakite ..	2·98
Pyrites	5·20	Chrysoberyl ..	3·76	Beryllonite ..	2·84
Zircon β ..	4·70	Pyrope	3·75	Turquoise ..	2·75
Spessartite ..	4·14	Hessonite ..	3·66	Labradorite ..	2·72
Almandine ..	4·05	Spinel	3·65	Beryl	2·70
Sapphire ..	4·01	Topaz	3·55	Amethyst ..	2·66
Zircon α ..	4·00	Diamond ..	3·52	Rock crystal ..	2·65
		Peridot.. ..	3·38	Iolite	2·63
		Spodumene ..	3·20	Moonstone ..	2·58
		Tourmaline ..	3·10	Opal	2·20

The following brief notes as to the physical or mechanical properties of minerals not already discussed or described must suffice.

Form.—The forms of crystals are all referable to one or other of these six crystallographic systems:—(1) The cubic or monometric; (2) the pyramidal, dimetric, or tetragonal; (3) the rhombohedral or hexagonal; (4) the prismatic, trimetric, or orthorhombic; (5) the oblique or monoclinic; (6) the triclinic or anorthic.

Structure.—The mode of mechanical aggregation or intimate texture of minerals may often be learnt by disruption of the mass, or by splitting or cleaving it. Structure is often crystalline, laminar, fibrous, or columnar. Fractured, not cleaved, surfaces are less instructive—they may be conchoidal, uneven, splintery, or hackly.

Transparency.—For want of a more comprehensive term, the various degrees of resistance to the transmission of light through minerals are included under this title. The degrees are five:

Transparent—when objects can be seen distinctly.
Semi-transparent—when objects can be seen dimly.
Translucent—when light, not objects, can be seen.
Sub-translucent—when light is transmitted through thin splinters.
Opaque—when light is not transmitted.

Lustre.—This character, although it needs some practice to discern it accurately, is of importance as an element not merely of the beauty, but also in the discrimination of precious stones. The terms employed to designate its various qualities are these:

Metallic,	as on	pyrites.
Adamantine,	,,	diamond.
Resinous,	,,	garnet.
Vitreous,	,,	emerald.
Waxy,	,,	turquoise.
Pearly,	,,	moonstone.
Silky,	,,	crocidolite.

Metallic and adamantine lustres are connected with high refractive indices. The colours of precious stones are discussed in chapter iv.

In the five tables which follow have been arranged certain physical data of precious stones so that they may be discriminated from one another by comparing their specific gravities, their behaviour when examined with the dichroiscope, and their hardness.

DISCRIMINATION OF PRECIOUS STONES.

WHITE STONES.

NAME.	DENSITY.	PLEOCHROISM.	HARDNESS.
Opal	2·20	None	6
Moonstone	2·58	,,	6
Rock-crystal	2·65	,,	7
Beryl	2·69	,,	$7\frac{3}{4}$
Phenakite	2·98	,,	$7\frac{3}{4}$
Diamond	3·53	,,	10
Topaz	3·57	,,	8
Sapphire	4·00	,,	9
Zircon	4·75	,,	$7\frac{1}{2}$

RED AND PINK STONES.

NAME.	DENSITY.	PLEOCHROISM.	HARDNESS.
Tourmaline (pink) ..	3·05	Strong	$7\frac{1}{4}$
Kunzite	3·18	,,	$6\frac{3}{4}$
Topaz	3·53	,,	8
Spinel	3·58	None	8
Pyrope	3·75	,,	$7\frac{1}{2}$
Ruby	4·00	Strong	9
Almandine	4·15	None	$7\frac{1}{2}$
Zircon	4·70	Weak	$7\frac{1}{2}$

ORANGE AND YELLOW STONES.

NAME.	DENSITY.	PLEOCHROISM.	HARDNESS.
Cairngorm	2·66	Weak	7
Beryl	2·69	Strong	7¾
Tourmaline	3·11	,,	7¼
Spodumene	3·20	Weak	6¾
Diamond	3·53	None	10
Topaz	3·53	Strong	8
Hessonite	3·66	None	7
Chrysoberyl	3·75	Strong	8½
Sapphire	4·00	,,	9
Spessartite	4·15	None	7¼
Golden Zircon	4·40	Weak	7½
Yellow Zircon	4·67	,,	7½

GREEN STONES.

NAME.	DENSITY.	PLEOCHROISM.	HARDNESS.
Emerald	2·70	Strong	7½
Aquamarine	2·70	,,	7¾
Jade	3·00	Distinct	6
Tourmaline	3·11	Strong	7¼
Hiddenite	3·15	,,	6¾
Jadeite	3·32	Distinct	7
Diopside	3·34	Weak	6
Peridot	3·40	Strong	6½
Epidote	3·44	,,	6½
Spinel	3·58	None	8
Alexandrite	3·65	Strong	8½
Demantoid	3·85	None	6
Sapphire	4·00	Strong	9
Zircon	4·05	Weak	7¼

BLUE AND VIOLET STONES.

NAME.	DENSITY.	PLEOCHROISM.	HARDNESS.
Lapis-lazuli	2·40	None	5½
Iolite	2·63	Strong	7¼
Amethyst	2·66	Weak	7
Beryl	2·69	Strong	7¾
Turquoise	2·75	None	6
Tourmaline	3·10	Strong	7¼
Topaz	3·55	,,	8
Benitoite	3·64	,,	6¾
Spinel	3·65	None	8
Sapphire	4·00	Strong	9
Zircon	4·65	Weak	7½

CHAPTER III.

CUTTING AND FASHIONING PRECIOUS STONES.

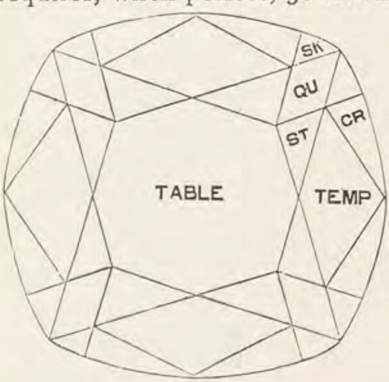
VERY few precious stones, as we receive them from the hands of Nature, present the beautiful qualities for which we look in these concentrated treasures of the earth. Often they are waterworn pebbles, roughened by attrition and blows during years or even centuries of wanderings in the beds of streams and rivers. If we find them intact in their rocky homes they are oft-times obscured with flaws and intruding matters which mar their beauty. If transparent and without speck or fracture, yet the natural forms in which crystallized gem-stones occur are but rarely adapted for direct employment in objects of jewellery. In shape or size they are awkward for such use, while many of those marvellous optical qualities which distinguish them from the crowd of commoner materials are brought into prominence only by the artificial processes of cutting and polishing. These processes convert rough crystals into shapely gems, having fine qualities of surface lustre and interior colour, and, withal, much less liable to fracture than the original stone. Now and then a perfect natural octohedron of flawless diamond or rosy spinel may be set in a ring or jewel ; but such instances are exceptional, and gem-stones, in order that all their elements of beauty may be developed to the uttermost, must be cut and polished according to rule.

All the different forms into which precious stones are cut may be arranged into the two groups—(1) those having plane surfaces; (2) those having curved surfaces: but, under special circumstances, facets or plane surfaces are occasionally associated with curved surfaces in the same specimen. The further sub-division of the two groups of forms may be tabulated thus:

Group 1. Plane surfaces	Brilliant-cut. Step or trap-cut. Table-cut. Rose-cut.
Group 2. Curved surfaces	Single cabochon. Double cabochon. Hollowed cabochon. Tallow top.

A few words descriptive of each of these modes of cutting stones may now be given.

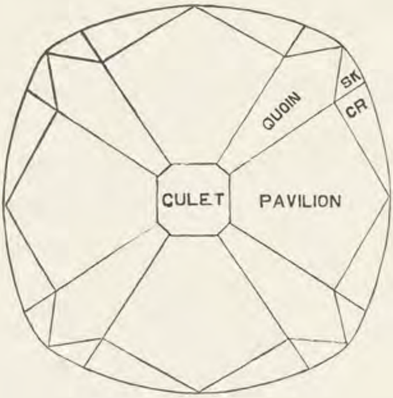
The old brilliant-cut, though susceptible of many small modifications as to the size of the facets, their mutual proportions and inclinations, and even their number, requires, when perfect, 58 facets thus arranged:—



1 Table 8 Star facets 4 Templets or bezels 4 Quoins or lozenges 8 Cross or skew facets * 8 Skill facets * — 33	The "Crown" or upper part of the brilliant.

Fig. 12.

* The cross and skill facets are sometimes called half-facets; the former are known as *clôtures* by the French lapidaries.



1 Culet or collet
4 Pavilion facets
4 Quoins
8 Cross facets
8 Skill facets
—
25

= The "Pavilion" or base, or under part of the brilliant.

Fig. 13.

There are thus 58 facets in a brilliant, while the "girdle" or edge bounding the widest part of the stone divides the crown from the base, and is concealed, in part at least, by the mounting or setting. This girdle must not be very thin (it is liable to be so in what are called "spread," that is, shallow stones), for then it may become chipped and break away during mounting. If it be thick, on the other hand, the brilliancy of the stone is lessened, and its material wasted by the concealment of a good deal of it in the mount. This form of cutting is reserved particularly for the diamond—so much so, that the word "brilliant" used alone signifies a diamond cut after this fashion. Of late years the girdle of brilliants has been made to approach a circular outline; the templets and quoins are nearly of the same size, and eight star facets are cut round the culet, thus making a stone of 66 facets. Certain rules have been laid down for the relative proportions, not only of the several classes

of facets in a brilliant-cut diamond, but also for the thickness of the finished stone in each and all its diameters. Thus 1-3rd of the total thickness should be occupied by the crown or upper portion above the girdle, 2-3rds being below. The table should be 4-9ths of the breadth of the stone, and the culet 1-6th to 1-5th of the table; but according to some modern experts, both these facets, but chiefly the former, may be reduced with advantage below these proportions. Two of the most famous diamonds of the world show large departures from the typical proportions of a brilliant: the Koh-i-nûr in its present form is far too broad for its depth or thickness; the Regent is a good deal too thick for its breadth. But the same rule of proportion, although it may hold good for such diamonds as admit of being subjected to it without extravagant loss of weight, must be modified with stones of other species, and especially with coloured stones. With colourless topazes, sapphires, etc., the surfaces and inclinations of the facets must be modified to suit the refractive indices and other optical constants of these minerals; with coloured stones, if pale (certain alexandrites for example), greater depth must be secured; if dark in hue, then greater "spread" and less depth (deep red garnets furnish instances).

The style of cutting known as the step-cut or trap-cut is adopted for the emerald and many coloured stones. It is subject to rules of proportion far less strict than those devised for the cutting of the diamond in the brilliant form. Each species of stone needs special study, that the typical step-cut may be so modified as to bring out the full beauty of the gem. The fault most common with step-cut stones is the too great breadth of the table, for

the internal reflections from the lower facets are best seen through the sloping bezels of the crown, not through the flat surface of the table.

In the step-cut (fig. 14), we have then a table, two or more sloping step facets, and then the girdle, while the lower part of the stone (fig. 15) is cut into three or more sets or zones of diminishing steps, with an oblong square or hexagonal or octagonal culet as termination. Some trap-cut stones are brilliant cut below the girdle, or *vice versâ*.

Fig. 14.

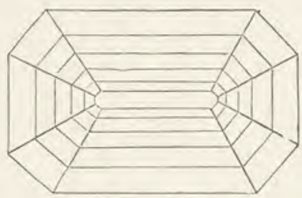


Fig. 15.

The table-cut needs little description: it has a very largely developed table with bevelled edge, or a border of small facets. It is employed for covering fine gold-work and miniatures; in the sixteenth century and later it was used in Europe for much diamond-work.

The rose-cut (fig. 16) shares with the table-cut a much greater antiquity than the brilliant-cut. It may be compared with the latter by supposing the table to be replaced by six triangular or star facets, and the crown to be represented by eighteen triangular cross and skill facets which together constitute what the French call *la dentelle*. The base is either flat or a duplicate of the upper part.

Fig. 16.

The other forms given to faceted stones are not of

sufficient importance to need description; the star-cut and the pendeloque may just be named as patterns sometimes followed in the cutting of diamonds.

Translucent and opaque stones are commonly cut *en cabochon* (fig. 17); the opal and the turquoise are characteristic examples. The moonstone, avanturine, cat's-eye, and star sapphire, too, would not show their peculiar properties were the confusing reflected lights from facets to be mingled with the white sheen, the brilliant spangles, the silver thread, or the six-rayed star which these stones respectively present when properly fashioned. The one transparent stone which is frequently cabochon-cut is the garnet, which is then called a carbuncle. A variety of cabochon used for this gem is somewhat hollowed behind (fig. 19), to receive a piece of foil as well as to lessen the depth of colour in very dark stones. Our figures represent the simple cabochon (fig. 17), the double cabochon (fig. 18), the hollowed (*évidé*) cabochon (fig. 19), and the flattened form much used for opals, and called tallow-topped (fig. 20). The double cabochon is usually cut with the base of lesser curvature than the crown; but with many stones a more brilliant play of coloured light within the stone may be secured by reversing these proportions. Although the cabochon form is almost essential to many precious stones, and is

Fig. 17.

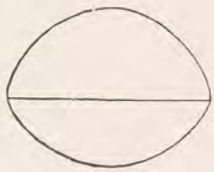


Fig. 18.

Fig. 19.

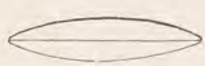


Fig. 20.

useful to hide the poverty and flaws of others, and also is convenient in the case of stones to be used in the decoration of vases and other objects to be handled, yet it ought not to be allowed to displace the various faceted forms. Doubtless there is a quiet beauty and richness in a good cabochon ruby, sapphire, emerald, or jargoon, but we lose some of the most striking characteristics of these gems when we so cut them as not to admit of the display of their dichroism, and their dispersive and reflective powers. The narrow view that all faceted stones are vulgar is based on caprice and ignorance; it is the mere unintelligent whim of a clique of artists and amateur writers on art. For the faceting of the great majority of transparent stones is an operation necessary for the development of those optical qualities upon which the beauty of precious stones mainly depends. It should be performed in strict accordance with certain rules of proportion, which may be deduced from the optical constants of each species of stone.

Information as to the mechanical processes, and the materials employed in the cutting and polishing of precious stones, may be found in the works of Jannettaz and Dieulafait. Horizontal wheels of steel, gun-metal, copper, lead, pewter, tin and wood charged with various grinding and polishing powders, are employed for different stones, and in different stages of the operations. The wheel, or disc, or lap, as it is called, is usually horizontal, and is made to revolve with great rapidity. The grinding or polishing powder, mixed, according to its nature, with olive oil or water, becomes partially embedded in the lap. This powder, in the case of diamonds, must be of diamond itself, generally in the form of boart, a dark and rather

porous variety of the mineral. The comparatively new and artificial compound of silicon and carbon known as carborundum is now largely used in the case of the harder stones, but emery, garnet-powder, tripolite, rotten stone, jeweller's rouge, pumice, putty-powder, and bole are in constant requisition for the grinding and polishing of stones less hard than the diamond. The whole subject of this mechanical treatment of stones, including splitting, dividing and shaping operations, is one which cannot be discussed here, involving as it does a large number of minute technical details of no interest from an artistic standpoint.

CHAPTER IV.

ARTISTIC EMPLOYMENT OF PRECIOUS STONES.

SOME acquaintance with the less obvious characters and qualities of precious stones, and especially with the distinctive properties of those kinds which remain practically unrecognized and unappreciated, may serve more than one good purpose. Not only may the jeweller's art receive new impetus and suggestion, but the buyers and connoisseurs of *bijouterie* may learn to appreciate more highly well-conceived design, new combinations, and exquisite workmanship. Most admirable and pleasant colour-combinations may be attained by the aid of materials which in many instances are now by no means costly. Curious and delicate hues of luminous and refined quality, preserved in enduring substance, may be arranged and grouped in forms of endless beauty and variety. Neither silks, nor paints, nor even enamels can ever equal the colours of precious stones in durability, or in brilliancy and pulsating variety of hue. And it cannot be doubted that when knowledge of the true nature of any art material (such as precious stones) becomes more intimate, exact, and diffused, a more intelligent and lively interest will be created in examples of good work wrought in the substance in question. Every connoisseur or collector of artistic objects must have shared in experiences of this kind. He may have been once quite dead to the peculiar merits of certain works, say in bronze, not even glancing at any specimens falling in his way. Then some casual

circumstance, perhaps an exciting contest for a fine piece of work at a sale between two enthusiastic collectors, or perhaps the gift of a choice specimen, may have drawn attention, not perhaps to the merits of such specimens, but at least to the esteem in which they may be held. Curiosity—it may be an intelligent curiosity—is excited. Investigation, more or less searching, follows. The hardness of the metal, its *provenance*, its designer, its age, the mode of manufacture, whether by casting or hammering; the manner of decoration, whether by chasing, engraving, or inlaying; the colour and texture of the surface, the presence or absence of *patina;* and not a few other points of interest, constitute the materials of complex study. Study provokes observation, and observation study, so that, before long, the neglected group of artistic bronzes exerts a kind of fascination upon the new votary. If his knowledge be superficial and inaccurate, or if he be merely an amateur or collector just because it is a fashionable pursuit to gather together or to admire certain classes of artistic objects, well, then, he does not really know what and why he admires. Forgeries delight him just as much as genuine works, so long as he is not sure that they are forgeries; but he has not sufficient patience for the mastery of, or sufficient insight into, the characteristics of true productions to discriminate them from those that are false. It often happens thus with the amateur of precious stones. He knows nothing of the optical elements say of surface lustre, and the pleochroism which go to make up the *tout ensemble* of any particular gem, and is quite satisfied with a well-cut bit of paste, or a cleverly contrived doublet. No doubt, in some cases, even an educated keenness of vision does not suffice to distinguish the true

stone from the false, although the durability of the genuine specimens will ultimately prove their superiority. But it is not difficult to learn to appreciate the peculiar and essential characters of the majority of the species of precious stones. The few simple pieces of apparatus, and the appliances described in the second chapter, will serve to supplement and correct the deductions of a trained eye and touch. And with a spectroscope, a polariscope, in addition to a good hand magnifier or pocket lens, such an array of evidence may be marshalled that there can remain but few cases in which the identity of a stone shall continue doubtful. But for the purpose of the artistic employment or appreciation of precious stones, such a table as that given on pages 6 and 7 will prove more useful than any recondite method of inquiry. Some of the uses of that tabular arrangement of conspicuous optical qualities may be gathered from the following examples. Referring to the shape of stones, we note that their boundaries are either *plane* or *curved*. Now if we have to use, in any piece of personal ornament, stones having curved surfaces, it will not answer, in general, to associate with them other curved surfaces, like those of the *en cabochon* moonstone ; and especially is this the case where the size of the stone, as well as the character of the curved surface, is nearly identical ; but a happier result will be attained by combining a step-cut stone with one having a curved surface. Again, citing an example from the series of adjectives expressing qualities of surface, it will be found that gems having an adamantine lustre assort better with those which present the less brilliant surface known as waxy, than they do with those which show a nearer approach to the adamantine surface, and

which are called resinous. The diamond and the jargoon do not improve or bring out each other's qualities, for they have too many points in common; but the diamond accords well with the pearl, and the jargoon with the turquoise, that is, the adamantine with the pearly, and the resinous with the waxy. Looking now into the substance of stones, rather than on their surface, their relations to the transmission of colourless light furnish many illustrations of wise and unwise, or effective and defective combinations. For example, chatoyant stones, like cat's eyes, do not associate well with translucent stones, like the chrysoprase and the chalcedony—the translucency of the latter confuses, because it resembles too closely, the chatoyancy of the former. But transparent stones accord well with all those which interrupt the passage of light by such internal reflections. The diamond, on this account, combines admirably with the cat's-eye and the pearl, but it affords too strong a contrast, especially when of large size, with the turquoise, to associate pleasantly with this nearly opaque stone. From amongst the qualities pertaining to the colour of stones, examples of the utility of the table may be cited. When a stone has much "fire" in it—that is, when its refractive and dispersive actions upon light are high—and it shows prismatic hues, then it looks best if associated with gems in which this property is less developed. Again, monochroic stones, which in all directions transmit beams of the same colour, should be associated with pleochroic stones, which exhibit two or more hues, while the latter should not be mixed together.

We are led from the study of these examples of associations of gem-stones to inquire into the principles

which underlie artistic combinations. Probably we are satisfied with arrangements of precious stones in which the leading *motif* is either identity, or seriation, or contrast. When stones match, when they are graduated, or when they offer a distinct but not startling contrast, the resulting effect is at least capable of being made satisfactory. When we speak of identity, seriation, and contrast, as expressing the elements of decorative association in the mounting of precious stones, we use words into which we are compelled to import special meanings. By identity, we mean that very close resemblance which selected specimens of choice stones of the same kind will exhibit ; seriation expresses the orderly sequence of tones or colours with the presence of a pervading and dominant element ; contrast implies an effect of change rather than of passage, and may include contrast of tone and of lustre as well as contrast of colour. Instead of further discussing the question of the artistic employment of precious stones in precise accordance with the three principles of association before laid down, a more useful and generally available plan will be to follow a classification according to *colour*. For as the ornamental or artistic employment of precious stones conveys primarily, if not wholly and ultimately, an appeal to the eye, it is clear that such optical properties as can be comprised in the terms lustre, light, and especially colour, should be our first consideration. After all, as, on the whole, the prominent feature of precious stones is their colour, so the easiest way of considering their colour is to adopt the order of succession of the colours in the ordinary rainbow or prismatic spectrum, beginning with the white light, which contains them all, and originates them all.

White Stones.—The diamond naturally takes the first position if we consider its hardness, its remarkable composition, and its strong refraction and dispersion of light. Its properties, so far as they appeal to the eye, differ much from those belonging to the majority of other stones, and it forms, partly in consequence of this peculiarity, as good a border or setting to other gems as a gold frame generally does to a picture. Of course, much depends upon the quality of the diamond, and much upon the shape which is given to it by the lapidary. The flat plates of *lasque* diamonds, and, in less degree, the step-cut stones with broad tables, exhibit the unique and splendid lustre which is peculiar to the polished surface of this stone; these forms also permit the transparency and the total internal reflection of light to be well seen. Even the form of the diamond crystal, the regular octohedron, when its surfaces are really planes, well exhibits the transparency and reflection of the stone. Next to the diamond we may place the colourless zircon or jargoon, then the phenakite, then the white sapphire, the white topaz, and the white beryl. Rock crystal will come below these in point of beauty and brilliancy. The colourless zircon sometimes approaches near in prismatic brilliancy to a diamond; so, at night especially, does the rare and curious mineral phenakite. There is, however, always a sort of difficulty in finding an appropriate use for colourless, yet lustrous, stones in any article of jewellery intended for personal adornment. The more lustrous and prismatic they are—the more they resemble the diamond, in fact—the less available are they for the usual purpose to which gems are put. Still, there are peculiar qualities in these stones which need not be lost to artistic employment, if the

white stones in question be judiciously associated with materials which prevent their being mistaken for diamonds. A white diamond should rarely or never be bordered by green tourmalines, but these stones would form an agreeable combination with a white zircon, a phenakite, or a white topaz. In the white sapphire there is often a faint suspicion of milkiness, and in the white beryl a cool greenish tint, which prevent these stones from resembling the diamond so closely as to be taken for imitations of that gem. But many of these colourless stones, notably the topaz and rock crystal, in all probability are most appropriately used when set as bosses in vessels and other large pieces of metal work, or employed in the form of plaques for engraving or etching. It is scarcely necessary to justify such uses of these minerals, and this is not the place to enter upon the question, particularly as it is only by a rather wide use of the term precious that I am able to include these materials, and some others which I shall have to discuss presently, amongst precious stones. Of two other white materials employed in jewellery, the moonstone and the pearl, a few words may be introduced here. The moonstone forms an excellent substitute in many combinations for the pearl, but it does not associate so well as the latter with the diamond. With deep-coloured amethysts, spinels, and tourmalines, few colourless gems look more refined than the moonstone. But these stones, which fetch a shilling or so apiece only, should always be accurately recut and highly repolished before being used. Their forms are too irregular and their surfaces too imperfect, as imported from Ceylon, to show off their moonlight sheen with half its intensity, unless they are

passed again under a careful lapidary's hands. The improvement thus effected is marvellous. The value of the pearl, whether its "orient" be luminous with prismatic hues, or whether it be a warm soft white merely, is too well known to be more than named in this connection. But we may be permitted to say one word in deprecation of the extravagant expenditure of time, of ingenuity, and of costly materials, which the attempt to convert large irregular pearls into structures resembling figures has so often caused. The result is nearly always most unhappy.

Red Stones.—The ruby may fitly be considered before other coloured stones. It, with the sapphire, and all the transparent varieties of corundum, ranks next to the diamond in hardness. It is, moreover, a stone of great beauty. Probably the experts in jewels are right in assigning the highest value to those rubies which possess a "pigeon's blood" colour—this is the orthodox hue. But the paler colours, and those which verge upon pink and crimson, and even violet, are capable of being so treated by means of association with white and black enamel or with dark stones, like olive-green tourmalines, as to lend themselves to the production of very beautiful decorative effects. The great mistake commonly made in the treatment of the paler rubies lies in the attempt to treat them in the same way as the deeper coloured stones.

It is difficult to describe the peculiar colour quality of the ruby in words. In fact, our nomenclature of colours is neither ample nor accurate. Our appreciation of delicate differences between colours is growing, but the language by which we endeavour to describe the hues which we have learned to appreciate is either stationary, or else receives additions from time to time of unsatis-

factory words, derived from the caprices of French fashions. The time has really arrived when a standard series of hues of all sorts should be constructed and appropriately named ; but, in the case of the ruby, the question of pleochroism comes in, and renders the difficulty of describing the colour quality of this stone greater. There is also some prismatic "fire" in the stone, and much internal reflection of light, while its surface lustre lies between resinous and vitreous. These four properties give to the red of the ruby a peculiar richness, which the two other species of precious stones—the spinel and the garnet—which come nearest to it in colour do not equally possess. The two reds which make up the colour transmitted by the ruby do not differ much, but yet they help to impart to a properly cut stone a delicate variation of hue which is not present in any other red stone, nor in any imitative substance. The dichroiscope, consequently, never fails to discriminate between a ruby on the one hand and a spinel or a garnet on the other. The two latter stones are, of course, softer than the ruby, and the former is always lighter, that is, of less specific gravity. For the ruby and the whole of the corundum family of stones have the specific gravity of 4, and a hardness which is nearly, and in some cases quite, 9 on the mineralogical scale.

One of the happiest uses of the ruby is in the form of an inlay in certain gold vessels of Indian origin. The external surface of these vessels is covered with a system of interlacing ridges and furrows. The rubies, generally small, oval, and cut *en cabochon*, are set along the furrows. Thus they are much protected from the chance of dislodgment, while the effect they produce, of a rich deep

crimson groundwork over which a gold netting has been thrown, is in perfect harmony with the materials and their workmanship. For, naturally, the metal gold, when pure, or nearly pure, throws a ruddy tint when light is reflected from surface to surface ; witness the interior of gilt vessels. The same thing occurs in the golden furrows of which we have spoken, where the rubies seem to rest in a golden sheen, of a hue in which the yellow, and orange, and red elements, now one and now another, appear to prevail. The gold should not be burnished where much contrast between the metallic surfaces and the rubies is desired, but the stones themselves should be as brightly polished as possible, in order not only to develop the full beauty and variety of their colour, but also the very considerable surface lustre which the ruby possesses. There is another kind of Indian jeweller's work to which most of the remarks I have just made apply. A perforated plate or disc of delicate arabesque or radiated work is found decorated with ruby beads, round or oval, attached to the circumference of the ornament, or else introduced into its midst in concentric circles. Here dull dead or "matt" gold is particularly appropriate, as affording a pleasant contrast to the rich, smooth, and soft transparency of the rubies, which, from the manner of their mounting, may be looked through. The refinement of the slender goldwork, which, in this class of jewellery, approaches the delicacy of filigree, sets off by its minuteness of detail the simpler and bolder forms of the plain, smooth, rounded stones, which give it colour and warmth. We must dwell for a moment or two upon another Eastern method of dealing with the ruby—the use of this stone as an inlay or onlay—that is, an incrustation—upon jade, both white

and green. It is not so much here a beautiful contrast of colour that is attained, although the greenish grey, or olive green of the jade, enhances the redness of the ruby; but it is a contrast of textures, a contrast of surfaces, a contrast of translucencies. You see but a little way into the jade, though it is illuminated by a soft diffused light; but you see through the clear deep-toned rubies, with their flashing beams of crimson.

Now compare with these examples of the artistic employment of the ruby the ordinary mode in which this stone is set by English jewellers. Look at the half-hoop ruby ring, with five rubies well matched in colour, and graduated exactly in size set close together in a regular row. You see, perhaps, a little speck of gold appearing here and there at each end of each stone, but nothing is made of these pieces of gold. You accept them because you know they are necessary to hold the stones in their places, but you find neither invention nor beauty in these little bits of gold claws. In fact, they are frequently prepared by the gross, ready for the mounting of any stones, provided the shape of the latter be suitable. Rubies, sapphires, diamonds, garnets, and emeralds are all set in the same way, not an attempt being made to adapt the amount of gold surface or its form to the specific nature of each gem. But why should not some variety and some appropriateness of mounting be secured for all stones? How exquisite, and yet how strong, were the gold and enamel settings of precious stones in the cinquecento time in Italy! Let those patrons who desire the rather barbaric splendour of masses of rubies gratify their taste by means of jewels in which the setting is not seen at all. But surely a fine stone is worthy of a fine and

originally designed setting—proportioning the latter in form, in amount of work and surface, and also in colour, whether red, or green, or yellow gold, or enamel, to the shape and the hue of the stone to be set. And even small stones become quite beautiful when arranged with taste and judgment, in accordance with the conditions just named, and with the further condition as to collocation of individual stones in accordance with their size and shape. In pendants, and necklets, and lockets, and brooches there is room for the expression of some definite and intelligible design. The mere alternation of rubies with diamonds in rows or chequer-work may, in some instances, achieve all that is needed. But a design of more definite form may often be preferable, especially where the stones at one's disposal are of differing colours and sizes. Then one may construct a suitable bit of leafage or flowerage, duly conventionalized, in accordance with the nature of the available materials, into forms of more or less geometrical severity. It should be noted that moonstones and white sapphires, in which there often lurks a faint opalescence, accord well with rubies; but it must be kept in mind that the size of the colourless stones which are to be associated with rubies in such designs as those named is a matter of much moment. It is a mistake to attempt to match the colourless and the coloured stones in respect of size, and generally of shape also. One should be smaller than the other. Large rubies with small moonstones or small rubies with large moonstones, and similarly, square stones with round, and oblong stones with round, generally produce happier effects than square with square, and oblong with oblong. Pearls accord with rubies, not only by reason of their

colour relations, but also on account of their shape. In the case of rubies cut *en cabochon*, brilliant-cut or square step-cut diamonds will be found to yield very satisfactory combinations. A border of small brilliants or roses is a usual and a useful mode of setting off the qualities of a ruby. The colour of the pale stone is heightened by contrast with the colourlessness of the diamonds; the richness of a rich stone is enriched, and a small stone, if surrounded by stones still smaller, becomes magnified in proportion.

Next to the ruby, amongst the red stones, comes the spinel or balas ruby, an entirely different mineral species, without any pleochroism, and inferior in hardness to the true ruby. The scarlet, aurora-red, and flame-coloured spinels are the most beautiful, those which verge upon crimson, purple, and violet, looking dull and black at night, but showing very delicate and often rare hues by day. Red spinels accord well with small brilliants, or with larger pearls or moonstones. A fine aurora-red spinel looks well when surrounded with delicate foliage of white, orange, and black enamels. Step-cutting, similar to that employed for emeralds, accords best with the optical qualities of this stone. A biconvex lenticular form may be so adapted to this stone as to throw a good deal of soft and rich colour into a specimen which would otherwise have had little beauty to recommend it. What richness of hue the finer examples of red spinel may show is to be studied in two specimens in the Townshend collection, Victoria and Albert Museum, Nos. 1326 and 1327.

From spinels the passage to garnets is easy. But it is not really difficult to discriminate between the two species, even when the colours seem the same. If you have a

ruby, a spinel, and a garnet together, the first will scratch the second and the second the third. The ruby will show two colours in the dichroiscope, the spinel and the garnet only one. The spinel will exhibit no black bands like those belonging to the almandine garnet when viewed with the spectroscope. And there is a blackness, due to much absorption of light, in many of the facets of a garnet, as seen from the "table" of the stone, which will not be observed in the spinel. The garnet, unless of remarkable size or quality, will hardly be deemed worthy of being mounted in the same costly way as the ruby or the red spinel, but it may be said that the same general treatment suits all these red stones. Yet there are two ways in which garnets have for long and in many places been treated, to which I may legitimately refer here. The plates of garnet so largely found in Anglo-Saxon and Celtic jewels have remained, in the majority of cases, intact to the present day. They afford, in their breadths of soft rich colour, a pleasing contrast to the minute filigree, granulated and enamel work with which they are generally associated. The other employment of the red garnet (and it may be traced back to a far earlier date than that just cited) is as a carbuncle—not necessarily foiled at the back. Cut *en cabochon*, slightly hollowed behind, and laid on a plain gold surface, the light, as of a glowing coal, quivers in the midst of a good stone. There is a lovely disc of antique gold set with five carbuncles in the Gold Ornaments room at the British Museum. In the centre is a round carbuncle boss; then four long pointed arms, much like elongated pears, radiate from this centre alternately with a somewhat similar series of *repoussé* arms, beaten up from the disc of gold,

and bordered with knurled wires onlaid. There is not much work in the piece; the intrinsic value of gold and garnets is quite small, but the effect is delightful; simple, yet rich; solid, yet elegant. Can the same praise be honestly given to modern garnet-work? Can we feel a genuine satisfaction either in the design, the execution, or the effect of a compound big carbuncle of eight lobes, with an eight-rayed star riveted into the midst of it, the aforesaid star being of hard, poor, glittering, much alloyed gold, and containing a number of irregular fragments of defective diamonds? The star soon gets loose, and later on the diamonds begin dropping out. But we will not pursue the history of the piece any further, and will refrain from calling attention to other obnoxious modes of using carbuncles, as in a ring with a sham gold knot on either side.

Orange and Yellow Stones.—Amongst orange and yellow stones we may assign the first place to the yellow zircon—a stone which is sometimes found of a hue which may be aptly described as that of transparent gold. Next to this comes the yellow sapphire, afterwards the cinnamon stone, or hessonite; and then we may place the rich sherry-coloured Brazilian topaz—that kind which yields when heated the finest rose-pink stones. Then the chrysoberyl follows, and at some distance the yellow beryl. Few colour combinations have been attempted with these yellow stones; puce-coloured spinels associate with the yellow sapphire very happily, but there are some enamels which answer equally well. Generally a design of pale bluish-grey enamel, with minor details wrought in buff and white, develops the richness of gold-coloured stones. Here mention should be made of the very rare gem, the

spessartite of Ceylon. It is of an orange-red hue, and is of most fiery brilliance, but is very seldom met with in commerce. The North American spessartites are inferior.

Green Stones.—There are four green stones about which something ought to be said—the emerald, the tourmaline, the peridot, and the zircon. Some persons regard the green of the emerald as vulgar. It is too easy to construct a vulgar, coarse ornament out of emeralds, even if they be of fine quality. But the emerald, step-cut and judiciously and quietly mounted, possesses a rich and refreshing colour, just sufficiently dichroic to show passages of bluish-green with the green. Green tourmalines are much more markedly dichroic, and it is much to be regretted that, with rare exceptions, the patrons of the jeweller's art still remain ignorant, not only of the peculiarly rich and varied qualities of the colour of the tourmaline, but even of the existence of this gem-stone. With moonstones, or with grey and ivory-white enamel, long prismatic tourmalines, carefully cut, afford a delightful colour-combination peculiarly fitted for larger pieces of personal adornment, such as pendants and brooches. The so-called green garnets of the Urals, especially those which are of an olive or pistachio green, are lustrous and fiery stones, but their softness precludes their use in rings. The same objection holds good with regard to that lovely stone the peridot; but this species occurs frequently of large size, and so is well adapted for employment in jewels not subject to much attrition. It is a dichroic stone; it accords well with small puce, violet, or indigo spinels, also with black and white enamel; small dark-coloured almandine garnets may sometimes be associated with peridots of fair size advantageously. The most beautiful of all green stones

are those choice green zircons which show a full velvety leaf green. These always have a low density not exceeding 4·15, and often no more than 4. They have the merit of appearing particularly bright by artificial light. White enamel, or a border of very small green zircons, enhances their beauty.

The aquamarine and other pale varieties of the beryl are stones which lose nothing of their brilliancy at night. Their beauty may generally be greatly enhanced by the judicious use of creamy white enamel with delicate arabesques of black or indigo blue. It is not often that the hue of the beryl is such as to bear the juxtaposition of other coloured stones.

Blue Stones.—Of these there are four that claim notice in this place—sapphire, blue spinel, iolite, and lapis-lazuli. Rich yellow dead-gold settings suggest themselves for most of these materials. Pearls or diamonds enhance the colour of the paler sorts of sapphire, spinel, and tourmaline, but afford too striking a contrast with very richly and deeply tinted stones. A fine indicolite, step or cabochon cut, accords well with pearls or moonstones arranged as a bordering or in some conventional form; the gold work may well receive an enrichment in the form of grey or olive green enamel. In the case of the sapphire, the twin beams of diversely-coloured light which this stone transmits—the one azure blue, the other greenish straw—contribute to produce the peculiarly rich quality of its velvety softness. There is a glittering coldness in all the imitations of the sapphire—the *timbre* of their colour, to borrow a word from music, is harsh and unsatisfactory. So a recent imitation, a kind of lime-spinel made artificially, exhibits apparently the right colour, but it is flat and

uninteresting. To my eye the difference between a true sapphire and a false one is the analogue of the difference between a piece of leafage in wrought iron and the same piece in cast iron. As to the arrangement of the sapphire in jewellery so much depends upon its depth of colour and its precise hue that a general rule would be fallacious. Unless it be pale, when certain green tourmalines go well with it, the sapphire may be most safely associated with pearls, diamonds, moonstones, or white topazes, the cutting and size of the stones being carefully studied.

Violet and Purple Stones.—The amethyst, the oriental amethyst, and the almandine garnet cannot, as a general rule, be safely associated with stones having strongly marked contrasting hues. The paler sorts of peridot may, however, be combined with deep-coloured amethysts or almandines, provided the latter be small in comparison. The use of opaque fawn-coloured, olive green, and brown enamel with violet and purple stones sometimes yields happy effects.

In devising arrangements of coloured stones a mere water-colour sketch will not suffice. It is always desirable to study with the aid of the actual materials themselves—stones, gold, silver, enamel—the sum of the effects due to lustre, texture, form, size, etc., as well as the balance and distribution of colour.

In any treatment, however cursory, of the topic of this chapter, the artistic employment of precious stones, some reference ought to be made to the materials used by the gem-engraver. Nearly all the minerals employed for intaglios and cameos will be found mentioned in a subsequent chapter. Most of them are varieties of silica coloured by small quantities of iron-compounds. Such

are the sards, cornelians, onyxes, chalcedonies, amethysts and jaspers in which the great majority of antique gems were wrought. An intaglio well engraved in one of the more transparent or translucent of these stones, say, on a rich golden or blood-red sard, shows effects of beautiful colour when viewed by transmitted light which will be sought for in vain in any faceted specimen. And then the cameos of later dates, wrought in onyx and sardonyx, present delightful contrasts of tone and hue in their different strata, utilized as these layers often were in the building up of a relief-picture. Of other minerals employed for engraving in classic times mention may be made of beryl, garnet and plasma; the harder and rarer stones were, however, little used until mediæval and later days. It is well to remember that the jacinth, properly so-called, that is the orange brown or brownish red zircon, has never yet been found with an engraving of classic date upon it; that the steatite of catalogues of engraved gems is for the most part serpentine, a harder mineral having an essentially different constitution; and that under the conventional term "plasma" several other minerals are included, such as jade and smaragdite, both varieties of hornblende, and even the beautiful rich green variety of serpentine known as antigorite.

CHAPTER V.

ARTIFICIAL FORMATION OF PRECIOUS STONES.

A CLEAR distinction must be made between the imitation of a precious stone and its actual reproduction or formation by artificial methods. In the former case we simulate the appearance of the natural substance by means of some product or preparation which may be (and generally is) widely different in chemical composition and even in many physical properties. In the latter case we form the very mineral which Nature has formed, endowed with all its chemical and physical characters, but not necessarily produced by processes identical with those of Nature. A few examples of the true reproduction of precious stones will serve to explain the distinction pointed out with sufficient exactitude.

Take the case of the ruby and sapphire, varieties of crystallized alumina or corundum. If, by the aid of the intense heat of the oxyhydrogen blowpipe, pure alumina, with traces of chromium oxide or other colouring oxide, be fused, we get a sapphire or ruby glass, having a hardness and density much less than those belonging to crystals of alumina. But by prolonging the time of cooling or by producing the alumina from some of its compounds during the heating, a portion of the product will crystallize in forms identical with those of the natural stone, and having the density of 4 and the hardness of 9. For some time the specimens made were small in size and poor in colour and brilliancy, but the product was identical with native

corundum. Now there have been, among the large numbers of artificially-prepared rubies, some of several carats in weight which can be distinguished from the natural stones only by a close examination with the microscope. It is then observed that the artificial rubies contain cavities of a different outline and nature to those which occur in the rubies made in Nature's laboratory. These cavities are more or less spherical or pear-shaped in the artificial ruby and their walls are curved; in the natural stone the cavities are really *negative* crystals, while their walls are angular. There are also curved instead of straight striæ in the artificial product. It was the French chemist Frémy who first made good small rubies artificially, but subsequent workers, by employing larger quantities of material, modifying the ingredients taken, and allowing the fused product to cool more slowly, have achieved greater success. It was Verneuil who in 1904 made the most striking improvements in the methods of producing crystallized alumina in the form of artificial ruby. His inverted oxyhydrogen blowpipe and his employment of *pure* alumina with a definite proportion of chromium sesqui-oxide were two of the chief factors of his success, but his elaborate system of conducting the fusion and the subsequent annealing process are of great importance in securing an almost complete crystalline uniformity in the resultant mass. After careful annealing this may be cut and polished, and then cannot be distinguished by the ordinary tests of hardness, dichroism, colour and density from natural ruby. But under the microscope it is possible to detect those peculiarities which have been named above as characteristic of artificial rubies. By the method of Verneuil blue corundum or sapphire may also

be obtained, the colouring material introduced for this purpose being a very small quantity of titanium oxide, about 0·12 per cent. Without any addition white corundum is the product; colours other than red and blue may be imparted by other metallic oxides.

In connection with the species to which ruby belongs it may be mentioned that clear colourless corundum or white sapphire is often made to take on decided colours by exposure for some time to the radiation from radium bromide.

The red spinel has also been made artificially, of good colour, and in large crystals. The spinel is a compound of alumina and magnesia, and by the aid of a substance such as boracic acid, which acts as a solvent for the constituents of spinel, but which volatilizes at very high temperatures, crystals of spinel having considerable dimensions, good colours, and the hardness of 8, have been obtained by several chemists. These stones, having been cut and polished, could not be distinguished by any test from the natural gems. Another method of operating, by which rock crystal and a considerable number of hard, transparent and beautiful compounds of silica have been made, consists in causing two substances to act upon each other when both are in the state of vapour, sometimes with the aid of the vapour of water as a decomposing agent, and sometimes without. By the reaction of fluoride of aluminium and boracic acid, fluoride of boron and alumina are produced, the latter crystallizing in colourless rhombohedra of white sapphire, or even, when chromium is added, taking the colours of ruby and blue sapphire. Similarly treated at a very high temperature in a lime crucible, the fluorides of aluminium and glucinum have

been made to yield distinct crystals of chrysoberyl. It is probable that in Nature the formation of gem-stones has occurred in the presence of water, and under very great pressure continued for a long time. Indeed, it may be concluded that the agency of a very high temperature has not been generally at work, but that the important elements in the production of natural crystals have been time, mass, and pressure.

Chemists have devoted much time and skill to devising methods for producing diamonds. These methods have rarely been successful, but the late Henri Moissan really made a number of small—very small—diamonds by causing carbon to dissolve in molten iron at the high temperature of the electric furnace, and then, by sudden cooling of the metallic mass, causing the formation of a rigid shell and so producing great pressure in the interior: the iron mass treated with acid left a residue containing small diamond crystals: by slow cooling graphite only was formed.

CHAPTER VI.

IMITATIONS OF PRECIOUS STONES.

THE one point in which all artificial imitations of precious stones fail is hardness. Practically they all yield to the file, and many are scratched even by a bit of common glass. Indeed, with rare exceptions they consist of flint glass, containing an unusually large proportion of lead and tinctured by the addition of certain colouring oxides, such as cobalt for blue, manganese for violet, as well as nickel, copper, iron, chromium, or mixtures of these for other hues. Colourless strass, as it is called, commonly contains 38 per cent. of silica, 53 oxide of lead, 8 potash, and traces of boracic and arsenious acid, with some alumina and soda. There are three other points in which these coloured glasses differ from true stones. Besides their softness already named, they tarnish in impure air, the lead becoming sulphided, and therefore brown; they are heavier than any of the stones having specific gravity under 3·3, which they represent, and they are all destitute of pleochroism. Under the microscope, or even a hand magnifier, the majority of them show many lines, and specks, and air-bubbles, which betray their origin and nature—their origin, at a high temperature rapidly reduced; their nature, as fused, glassy, non-crystalline masses. The lines and striæ are signs of layers of unequal density and of strain; the bubbles are rounded cavities, quite different from those cavities, with angular and crystalline walls, which some gem-stones, such as amethyst,

beryl, topaz, frequently present. This is true not only of the many varieties of coloured paste or "strass" which form the usual materials for imitative gems, but also of the fused compounds having the precise (or at least analogous) chemical composition of various gem-stones which have been prepared by Mr. Greville Williams and M. Feil. The green beryl glass of the former, and the blue lime spinel of the latter, afford cases in point.

Instead of substituting a wholly imitative preparation for a true stone, a doublet or triplet is constructed, in which a colourless or pale stone, of no value, is made to appear possessed of a fine deep colour. The doublet sapphire has a table and crown—all the stone down to the girdle—of colourless or pale blue sapphire, then the lower part of the combination, attached by cement, is made from blue glass or strass. If then the upper part of the stone be tested for hardness it answers to that of the sapphire, but if the base be examined, it immediately betrays its softness. To avoid this the triplet has been devised. Here we have pale sapphire for crown and base, but a thin layer of deep blue glass at the girdle—a part generally hid by the mount. To detect this imposture immersion in water generally suffices, for then the three layers will become visible; and if a doublet or triplet be boiled in water, or soaked in a small bottle of chloroform, it usually betrays its composite nature by falling to pieces. We should add that some false stones of this sort are coloured by means of a layer of coloured varnish or cement.

Imitation pearls claim a word of description. They are small spheres blown on tubes of slightly opalescent glass, and coated internally with a preparation made from

the scales of a certain fish (as the bleak), and called Essence d'Orient. Into the little opalescent glass globe a coating of parchment size is introduced, and then a film of the pearl essence. Lastly, when the essence is dry, the bead is filled with wax. In order to produce an appearance like the *orient* of the true pearl the glass globes before filling are sometimes heated under pressure with a hydrochloric acid solution; in this way an iridescent surface effect is produced.

Some remarks on the artificial colouring of natural stones will be found in chapter vii.; the different varieties of silica—agate, onyx, cornelian, and even opal—are frequently subjected to processes of heating and saturation with chemical reagents in order to change their hue or to introduce foreign colouring matters.

CHAPTER VII.

DESCRIPTIONS OF PRECIOUS STONES.

DIAMOND.

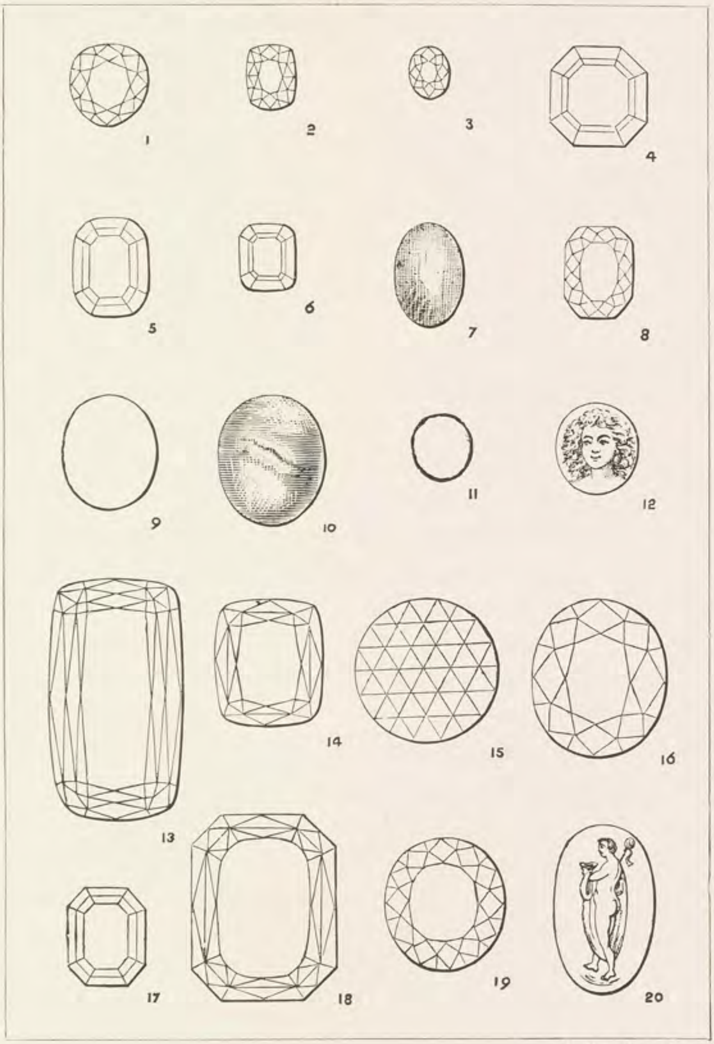
THERE are three characters which unite to place the diamond in a unique position amongst precious stones. It is the only gem which is combustible; it is the hardest of all minerals; it exerts upon light the most energetic refractive and dispersive power.

The diamond belongs to the cubic or isometric system, and usually occurs in the form of an octahedron, or in combinations in which the cube, the dodecahedron, and the tetrahedron are involved. The faces of these forms are commonly curved: macled and hemitropic associations of crystals are of frequent occurrence.

The diamond is easily cleaved in directions parallel to its octahedral faces. Its fracture is conchoidal. Its hardness is 10.

The lustre both of natural and artificial surfaces of diamond is peculiarly brilliant, approaching that of such a metal as silver. This characteristic lustre, which is shared to some extent by sphene, jargoon, and garnet, is known as *adamantine*—it lies between the metallic and the resinous lustres. The peculiar brilliancy of diamonds results in part from the total reflection of light from their internal faces when the incident light strikes them at an

PLATE I.—Diamonds, Corundums, Turquoise, Topazes, Tourmalines, Garnets.



To face page 64.

angle greater than 24° 13′. Diamond refracts light very strongly—the index of refraction for the yellow ray being 2·419, while that of rock crystal is but 1·545; of topaz, 1·621; of white sapphire, 1·75; of phenakite, 1·675; and of white zircon, 2. In the extent to which diamond disperses the several coloured rays into which white light is split, this gem greatly surpasses all others. Its "fire," or the flashing of prismatic hues which characterizes this precious stone, is mainly due to this dispersive power.

Sir William Crookes mentions that a green diamond in his collection emits, when exposed in vacuo to a high-tension current, a pale green phosphorescent light equal to that of a candle. Under these circumstances many diamonds emit a bluish light, some phosphoresce in the dark after having been exposed to sunlight, and some give out light by friction. The absorption-spectrum of diamond presents three bands in the ultra-violet region—these may be photographically detected. Diamonds generally present a single band in the violet at wave-length λ 4155. Diamonds often acquire colour by long exposure to radium bromide: the diamond is singularly transparent to Röntgen-rays.

The specific gravity of the diamond, when transparent and colourless, is of remarkable constancy. When taken in the ordinary way, without the refinement of certain small corrections which are made only for scientific purposes, the best results have lain between the narrow limits of 3·52 and 3·53, at 60° Fahrenheit. The fine colourless Porter Rhodes diamond has the specific gravity 3·523: the smaller but equally fine Gor-do-norr, 3·527. The former stone was found at Kimberley, South Africa, on the 12th of February, 1881, and weighs 474 troy grains:

the latter is of Indian origin, and weighs 213½ grains. The Star of the South, a Brazilian stone of 254½ carats, has the specific gravity of 3·529, according to M. Halphen.

The range of colour of the diamond is extensive; but various hues of yellow, greyish yellow, brown, and straw colour, are the most common. Strongly-coloured diamonds are very rare; but green, blue, and even red stones are known. The celebrated Hope blue diamond, of 44¼ carats, and the Brunswick blue diamond, of 6½ carats, are both of the same brilliant and steely blue, and may very likely have both been parts of the French blue diamond stolen from the Garde-Meuble, in 1792, and never since seen. The Hope diamond was sold in Paris, June 24th, 1909, for £16,000.

The least valuable diamonds are those which lack brilliancy, or have faint hues of grey, brown, and yellow. The most prized are those which combine brilliancy with decided tints of rose, green, or blue: cinnamon-coloured, salmon, or puce diamonds are also much esteemed. But pure diamonds, without flaw or tint of any sort, are those which are regarded as coming up to the market standard of excellence, and are spoken of as of the "first water." But even under this designation there is room for considerable diversity of quality, and consequently of price. And there are occasionally met with stones of such exceptional purity and beauty that the ordinary rules of valuation applicable to stones of the "first water" do not hold good. This observation, of course, refers to cut stones, that is, to well-proportioned brilliants. Such a stone, weighing but 1 carat (3·17 grains), might fetch £30 at a time when a first-water brilliant of the same weight would not realize above £20. In fact, specimen stones, like

exceptionally large stones, cannot be said to be amenable to any precise rule of valuation. The value of the diamond increases in an increasing ratio with its weight up to stones of moderate size, beyond which no rule holds good. Assuming a first-water brilliant of 1 carat to be worth £20, then an equally fine 2-carat stone would fetch £60, or £30 per carat. Formerly, the value of the larger brilliants increased so rapidly with their weight that a stone of 10 carats was worth over £200 per carat. But since the South African diamond fields have been extensively worked, large stones have been found in greater abundance, and have not maintained their relatively high prices.

In the preceding paragraph brilliants of the first water have been considered, but it should be added that the diamonds used in ordinary shop-jewellery, being either dull, flawed, or "off-colour," possess small market value. Reference may here be made to a trick by which the yellowish hue of a diamond may be temporarily masked. The back facets of the stone are lightly rubbed with a violet-blue wax pencil and the colour distributed by means of a bit of soft paper. The stone is then returned to its setting, when it will appear nearly white, the blue material correcting the yellow hue of the gem.

For the localities where diamonds have been or are found reference may be made to the works named in the brief bibliography in the present manual. The story of the diamond-fields of the world is full of romantic interest. India, Brazil, Borneo, and South Africa have all furnished most curious contributions to the long list of adventures, discoveries, and disasters connected with the diamond.

Until January 25th, 1905, when the Cullinan diamond

weighing $3{,}025\frac{3}{4}$ carats, or $621\frac{1}{5}$ grams, was found in the Premier mine 20 miles W.N.W. of Pretoria, the largest known diamond was that from the Jagersfontein mine, Orange River Colony, discovered on June 30th, 1893. It weighed $969\frac{1}{2}$ carats, but owing to an imperfection the largest brilliant cut from it weighed only $67\frac{7}{8}$ carats. It has been called the "Jubilee" and the Reitz diamond, and is of high quality. The largest diamond found at Kimberley was an octahedron of 503 carats, but this stone was full of black spots. Amongst the diamonds obtained from the River Vaal diggings the largest is a rounded pebble weighing $330\frac{1}{4}$ carats, but it is not of good quality. The Cullinan diamond above referred to is now known as the Star of Africa. It has, however, been cut into several stones of which the two largest are:

I. A pendeloque brilliant of $516\frac{1}{2}$ carats.

II. An oblong brilliant of $309\frac{3}{16}$ carats.

There are other gems of 92 and 62 carats respectively, as well as many smaller stones.

It has been estimated that the value of the diamonds added to the world's stock from the South African mines is more than £85,000,000. Even in one year (1903) the value of diamonds exported from Cape Colony was close upon £5,500,000. By the side of these figures the yields in ancient days of India, and, since the year 1725, of Brazil, do not seem large. At the present time diamonds are still found in Brazil, while new sources have been discovered in New South Wales, Borneo, Lüderitz Bay in German South-West Africa, and British Guiana. From the last named colony 173,744 stones were exported in 1902, but they were very small, for they weighed altogether no more than 11,518 carats.

The winning of diamonds and their mode of occurrence in the South African diamond fields are fully discussed in the volume of Mr. F. Gardner Williams on "The Diamond Mines of South Africa." Here it must suffice to state that the De Beers' and Kimberley *floors* whither the "blue ground" is conveyed, and where it is spread out to weather, cover an area of two thousand acres. Here the blue ground is harrowed, and if necessary watered. After various crushing, washing and screening operations, a material is obtained in which the diamonds have become concentrated. This passes at last into a remarkable machine called the *Greaser*. The mixture of pebbles, which we may call the concentrate, contains many minerals other than diamonds, such as garnet, ilmenite, enstatite, chromite, zircon, kyanite, diopside, and half a dozen other species, varying in density from 2·6 to 5·3. When this mixture flows in a current of water on to a series of sloping cast-iron rocking planes covered with a thick layer of grease, the diamonds adhere to the grease, while the other minerals, both those which are heavier and those which are lighter than diamond, are carried forward and away. Bits of metal and of iron pyrites do get embedded in the grease along with diamonds, and if any corundum were present it would also remain, but the separation of these substances from the grease and from the diamonds is quite easy. The grease loses its adhesive power by becoming superficially incorporated with minute portions of water, and then needs remelting and re-spreading on the oscillating "greasers." This discriminating process is based upon the differing surface-attractions of certain minerals for water on the one hand, and for oily and greasy materials on the other. In simpler

words diamonds and a few other minerals such as sapphires are apparently more easily oiled than wetted, while the far greater number of minerals are more easily wetted than oiled.

The following table gives some particulars concerning a few of the best-known and most important cut diamonds above 100 carats in weight. The figures quoted are carats, but are probably not in all instances based upon one exact standard—

NAME.	ORIGIN.	WEIGHT IN THE ROUGH.	WEIGHT WHEN CUT.
Star of Africa or Cullinan ..	S. Africa ..	$3{,}025\frac{3}{4}$	I. $516\frac{1}{2}$ II. $309\frac{3}{16}$
Nizam	India	—	277
Jubilee	S. Africa ..	634	239
De Beers of 1888	S. Africa ..	$428\frac{1}{2}$	$228\frac{1}{2}$
Kimberley, before 1898 ..	S. Africa ..	$352\frac{3}{4}$	$199\frac{3}{4}$
Orloff	India	—	$194\frac{3}{4}$
Darya-i-nûr	India	—	186
Victoria or Imperial ..	S Africa ..	$457\frac{1}{2}$	180
Taj-i-mah	India	—	146
Regent or Pitt	India	410	$136\frac{7}{8}$
Austrian Yellow	India	—	$133\frac{1}{4}$
Star of the South	Brazil	$254\frac{1}{2}$	$125\frac{3}{4}$
Tiffany Yellow	S. Africa ..	—	$125\frac{1}{2}$
Stewart	S. Africa ..	$288\frac{3}{4}$	120
Julius Pam	S. Africa ..	$241\frac{1}{2}$	120
Koh-i-nûr	India	—	$106\frac{1}{16}$

Full discussions of the history of most of these diamonds and of many others will be found in the works named in the Bibliographical Notes. Dr. Max Bauer's "Precious Stones" contains a good set of figures representing most of the celebrated big diamonds of the world. A large uncut Cape stone, given to the British Museum

by John Ruskin and named after Bishop Colenso, is a good octahedron of $129\frac{2}{3}$ carats.

Diamonds and the more valuable of precious stones generally are bought and sold by the weight called a *carat*. This carat, whatever its precise value, is always considered as divisible into 4 diamond grains, but the subdivisions of the carat are usually expressed by the vulgar fractions, one-fourth, one-eighth, one-twelfth, one-sixteenth, one-twenty-fourth, one-thirty-second, and one-sixty-fourth. The origin of the carat is to be sought in certain small hard leguminous seeds, which, when once dry, remain constant in weight. The brilliant, glossy, scarlet-and-black seed of *Abrus precatorius* constitutes the Indian rati, about 2 grains; the *Adenanthera pavonina* seed is about 4 grains. The seed of the locust-tree, *Ceratonia siliqua*, weighs on the average $3\frac{1}{6}$ grains, and constitutes, no doubt, the true origin of the carat.

The carat is not absolutely of the same value in all countries. Its weight, as used for weighing the diamond and other gem-stones in different parts of the world, is given, in decimals of a gram, by the majority of the authorities, as—

Madras	·2073533	France	·2055
Vienna*..	·20613	England	·205409
Frankfort	·20577	Spain	·205393
Brazil and Portugal ..	·20575	Holland†..	·205044

Assuming the gram to correspond to 15·43235 English grains, an English diamond carat will nearly equal to 3·17 grains. It is, however, spoken of as being equal to 4 grains, the grains meant being "diamond" grains, and not ordinary troy or avoirdupois grains. Thus a diamond

* Schrauf gives ·2057. † Schrauf gives ·20613.

grain is but ·7925 of a true grain. In an English troy ounce of 480 grains there are $151\frac{1}{2}$ carats; and so it will be seen that a carat is not indeed quite 3·17 grains, but something like 3·1683168 grains, or, less exactly, 3·168 grains. Further, if we accept the value in grains of one gram to be, as stated above, 15·43235, and if there be $151\frac{1}{2}$ carats in a troy ounce of 480 grains, it will follow that an English diamond carat is ·205304 of a gram, not ·205409, as commonly affirmed. By recalculating the value of the diamond carat, as used in different parts of the world, into its scientific equivalents in the metric system, the weight to four places of decimals will become, according to Mr. Lowis D'A. Jackson*—

Turin	·2135	Holland and Russia	·2051
Persia	·2095	Turkey	·2005
Venice	·2071	Spain	·1999
Austro-Hungary	·2061	Java and Borneo	·1969
France	·2059	Florence	·1965
Portugal and Brazil	·2058	Arabia	·1944
Germany	·2055	Egypt	·1917
England and British India	·2053	Bologna	·1886

From time to time attempts have been made to assign a definite weight to the carat wherever used. For instance, it was suggested in 1871, and confirmed in 1877, by the diamond merchants of London, Paris and Amsterdam that a diamond carat should equal ·205 of a gram. This value has now been largely superseded by the "metric" carat of one-fifth of a gram, or 0·2. This has become the legal standard in France, Holland, Denmark, Japan, and many other countries. The English, or Board of Trade carat, however, still remains at the rather high figure of 0·205304 gram.

* "Modern Metrology," p. 377.

It may be imagined that the diamond does not lend itself readily to the art of the gem engraver, still several engraved diamonds exist. Of these, two signets are preserved in the Royal collection at Windsor. One representing the Prince of Wales plumes was cut for Charles I. when Prince of Wales, the other and more important specimen is the armorial signet-ring of Queen Henrietta Maria. This had found its way into the last Duke of Brunswick's collection and then became the property of the city of Geneva. The late Dr. Drury Fortnum bought it and presented it to Queen Victoria. It was engraved in January 1629 to the order of Charles I. by one Francis Walwyn, who received the sum of £267 for his work and for the cost of the *boart* used. There are other engraved diamonds, mostly of the seventeenth century, of European workmanship in various museums and Royal treasuries, but neither from the artistic nor mineralogical standpoint are they of much importance.

Diamond is represented in the Townshend Collection by eight specimens :

Diamond. A natural crystal of octahedral form, having curved faces, and with its edges replaced, and so passing into a dodecahedron; $\frac{1}{3}$ in. diam.; claw setting on swing mount. 1172—'69.

Diamond. Black, brilliant-cut, nearly circular; $\frac{1}{4}$ in. diam.; bordered with 14 small roses; coronet mount. 1173—'69.

Diamond. Colourless, brilliant-cut, nearly circular; $\frac{5}{12}$ in. diam.; silver claw setting, on chased gold shank. 1174—'69.

Diamond. Honey yellow, brilliant-cut, circular; $\frac{5}{12}$ in. diam.; with 8 roses, one on each point of the coronet mount. (Hope catalogue, p. 27, No. 19.) Plate I. fig 1. 1177–'69.

Diamond. Pale greyish green, brilliant-cut; $\frac{5}{16}$ in. by $\frac{1}{4}$ in.; with 6 roses, one on each point of the Coronet mount. (Hope catalogue, p. 28, No. 24.) Plate I. fig. 2.
1176—'69.

Diamond. Bluish grey, brilliant-cut, circular; $\frac{1}{4}$ in. diam.; bordered with 12 brilliants set in silver, on gold mount.
1175—'69.

Diamond. Pale indigo blue, brilliant-cut; $\frac{9}{16}$ in. by $\frac{7}{16}$ in.; bordered with 12 + 6 = 18 brilliants. 1179—'69.

Diamond. Pale pinky cinnamon hue, brilliant-cut; $\frac{3}{16}$ in. by $\frac{1}{8}$ in.; bordered with 12 small brilliants set in silver, on the openwork mount. (Hope catalogue, p. 27, No. 15.) Plate I. fig. 3. 1178—'69.

Corundum.

Sapphire, Ruby, and Oriental Amethyst.

Next to the diamond in hardness must be placed the many varieties of the species called corundum. This includes the sapphire, the ruby, the oriental amethyst, the oriental topaz, and a whole crowd of stones, practically identical in composition, but presenting great diversity in colour and optical properties. All these varieties belong, however, to the mineral species corundum, the French *corindon*, and consist of crystallized alumina, the oxide of the metal aluminium. From the mineralogical, or rather from the physical point of view, the colour of these stones is of no account, while chemistry has not as yet succeeded in discovering much concerning the causes of the variations of colour which determine the very different values set upon different specimens of corundum. That there are small quantities of magnesia,

oxide of iron and silica in rubies and sapphires of all hues, has been ascertained, but this fact does not furnish the clue to the cause of the blue of the sapphire or of the red of the ruby. That certain chromium compounds impart a red hue to certain artificial preparations, both crystallized and vitreous, of alumina, will not count for much in the absence of proof that all rubies contain chromium. That iron is the cause of the dark colour of emery and other impure corundum is, however, certain: indeed some specimens of emery contain half their weight of iron oxide.

Coloured corundums, when strongly heated, generally change their hue, pale blue and pale yellow stones becoming colourless, and violet stones retaining only the red constituent of their original colour. In Ceylon the native dealers frequently offer for sale specimens exhibiting a beautiful pink or rose colour which is not natural, but has been produced by "firing" inferior corundums of the purple variety or oriental amethyst.

Corundum always occurs in crystals or is at least crystalline; the forms are six-sided prisms or pyramids belonging to the hexagonal (rhombohedral) system. The lustre is vitreous except on the basal planes, which are often pearly. The six-rayed star seen in many cloudy sapphires and rubies, especially when cut *en cabochon* with the summit of the curved surface lying in the direction of the principal axis of the prism, is due to the peculiar intimate structure of the crystal. In such a case some of the incident light is reflected regularly either from the internal surfaces of the layers which make up the crystal, or of minute cavities or inclusions therein. When this chatoyant lustre is very marked it gives us the "asterias"

or star-stones known as star-rubies when red, and star-sapphires when blue or grey; the star-sapphire is the *ceraunia* of Pliny.

Large rough crystals of pale blue sapphire from Ceylon, usually waterworn, but still retaining their hexagonal form, are employed for rock drills and for other mechanical appliances and instruments. Some of these crystals weigh as much as a pound avoirdupois. The smaller specimens often exhibit one or more zones of blue in planes perpendicular to the principal axis of the prism, while surface striations in the same sense are very common. Very rarely true twins occur, but not infrequently two or more crystals are associated by interpenetration. Cavities, generally of microscopic size, abound in these large cloudy crystals; in a few instances, a liquid with a bubble of gas or vapour may be seen in a cavity of large size. The cavities have angular walls, and occasionally may be regarded as "negative" crystals. What is termed the "habit" of corundum-crystals differs much in the case of specimens occurring in different localities. For example, while the Ceylon sapphires exhibit a form prismatically developed—a hexagonal bi-pyramid—the specimens from the Helena district on the upper reaches of the Missouri in Montana, U.S.A., are flat crystals in which the basal planes of the rhombohedron are conspicuous.

The hardness of pure transparent corundums, whatever their colour, is generally given as 9. In reality, there are differences in hardness between specimens from different localities and of different hues. As a rule, the true, rich, red ruby can be slightly scratched by white, blue and yellow sapphire, yet, on the other hand, if a lapidary be

questioned on this subject of relative hardness he may tell the inquirer that out of ten corundums from rings which he receives to restore their lost polish, nine will be sapphires and only one a ruby.

The specific gravity of pure, transparent corundum, including the colourless, yellow, red, and blue varieties, is as nearly as possible 4, the extremes being about 3·97 and 4·05 respectively. A fine yellow stone without flaws gave 4·006.

All corundums possessing a distinct colour are invariably dichroic. By this property rubies can be at once discriminated not only from garnets, but also from spinels. The dichroiscope shows, with the true ruby only, two differently coloured squares. Similarly the sapphire can be thus distinguished from the blue spinel, and of course from blue paste. The twin-colours, polarized in opposite planes, are these—

Sapphire * "cornflower" blue	Greenish straw yellow. Deep ultramarine blue.
Ruby † "pigeon's blood" red	Aurora red. Carmine red.

There can be no doubt that part, at least, of the peculiar beauty of fine rubies and sapphires is due to the play of different hues caused by their dichroism.

The ruby, when of perfect colour and fair size, is more valuable than any other precious stone save the emerald. If a diamond of five carats be worth £350, a faultless ruby of the same weight would sell for £3,000 at least. A very fine stone of a single carat may be worth as much as £100. All or nearly all the fine rubies met with in collections are believed to have come from Burma. The district of

* Frontispiece, Fig. 1. † Frontispiece, Fig. 2.

Mogok, in Upper Burma, in a mountainous region, includes the most important ruby-tract. The town of Mogok is itself ninety miles N.N.E. of Mandalay. Two very fine stones from this locality reached England in 1875. When recut they weighed $32\frac{5}{16}$ and $39\frac{9}{16}$ carats respectively. The rubies from Siam are, as a rule, not only too dark in colour, even verging on a brownish red, but they are also slightly cloudy. A large cut ruby, probably from Burma, was offered for sale at Christie's auction rooms on May 7, 1896. It weighed $46\frac{3}{4}$ carats, and was of an oblong form; its colour was somewhat inclined to purplish red and was not very bright. This unusually large ruby fetched £8,000, or at least it was knocked down or bought in for that sum. It should be added that this stone was rather clumsily mounted, with four fine large brilliants, as a brooch. Although Ceylon does not produce many fine or large rubies, a very beautiful specimen was lately found in the island. It weighed $4\frac{1}{4}$ carats, and was at first thought to be an extraordinarily fine spinel. Its colour is difficult to describe, but perhaps the phrase "deep dark scarlet" indicates its hue.

Sapphires, that is blue sapphires, are not only more abundant than rubies, but they are more frequently found of large size. In Siam and Ceylon occur the chief localities for fine sapphires, but inferior, or we should perhaps say less important, specimens are met with in many parts of the world. An important locality is in the Zanskar range in Kashmir; several others have been discovered in the United States. One of these is a comparatively new locality, some distance from the original sapphire district in Montana. It now yields many small sapphires of a uniform and fair blue colour. These stones

have not the rich velvety cornflower blue which is most esteemed, but they possess the merit of remaining bright and glittering under artificial light. Now and again, however, a specimen from the same locality, and of the same blue colour by day, is found to present a purplish hue at night. In Australia, especially in Queensland and New South Wales, sapphires occur in several localities.

Sapphires, even when of the finest blue, do not increase in value with their size to anything like the same degree as rubies: indeed, a sapphire of perfect hue and tone shows to the greatest advantage when of quite moderate dimensions; if very large, it may appear almost black, especially at night. Again, large sapphires are far more common than large rubies. A fine sapphire of 1 carat is worth considerably less than a perfect diamond of 1 carat; its market value may be put down as about £10. There were fine large sapphires in the possession of Lady Burdett-Coutts; the Duke of Devonshire owns a stone of 40 carats; a good rose-cut sapphire may be seen in the Mineral Gallery of the British (Natural History) Museum, while in the collection of minerals in the Jardin des Plantes of Paris is the famous Rospoli sapphire weighing $132\frac{1}{16}$ carats. The *saphir merveilleux*, formerly in the Hope collection, is not a typical specimen, for it is pale in colour and assumes an amethystine hue at night. Still, in its original form, an octagon $\frac{5}{8}$ths of an inch across, and weighing nearly 24 carats, it presented features of interest. It had once belonged to Egalité, Duc d'Orleans; it brought 700 guineas when sold at Christie's on May 12, 1886. Unfortunately it has been since recut.

The sapphire was engraved sometimes in the later Roman days, but more frequently in the cinque-cento

time. The pendent sapphires in the votive crowns of the Guarrazar treasure (7th century) in the Cluny Museum, and those on the front of the Pala d'oro in the church of Sant' Ambrogio at Milan (8th century), are of Indian origin, perforated and roughly polished, but not faceted. Small polished sapphires *en cabochon* are frequently found set in gold rings of stirrup form, and having a projecting bezel—worn by lay persons as well as by ecclesiastics in the 13th and 14th centuries.

Amongst the rarer corundums is the pure green sapphire or oriental emerald. But greenish and greenish blue corundums, generally pale, as are most of those from Montana, or somewhat inclined towards an olive hue, like the majority of the green sapphires from Ceylon, are by no means uncommon. The true oriental amethyst or purple sapphire is occasionally met with of a full tone; it is an interesting and beautiful stone, strongly dichroic, and often made up of alternate layers of ruby and sapphire. Violet specimens of poor quality are generally "fired," so as to change them into pale rubies. White sapphires of perfect purity do not seem to be common; a fine specimen of 26 carats is in the author's collection, but there is not a single good cut example in the Jermyn Street Museum, the Natural History Museum, or in the Townshend collection.

While the ruby holds its own by candle and gas light, the sapphire generally becomes dull, often acquiring a somewhat purplish or amethystine hue.

The white sapphire of modern writers is, in all probability, included under the *adamas* of Pliny; the blue sapphire is the ancient *hyacinthus;* while the true ruby, the spinel, and certain red garnets were the several

varieties of Pliny's *carbunculus*, under which name the writer included several stones which were perfectly distinct from one another.

In concluding this account of the transparent varieties of corundum, mention may be made of the extreme ingenuity with which, in a pale or poor coloured sapphire, the native lapidary in Ceylon will take advantage of the presence of a streak or spot of rich colour. He will so cut the stone as to throw this colour into the entire gem.

Corundum (including Sapphire and Ruby) is represented in the Townshend Collection by twenty-six specimens:—

Sapphire. White, with very pale bluish grey hue, faceted, octagonal; $\frac{17}{32}$ in. diam.; coronet mount. (Hope catalogue, p. 40, No. 19.) Plate I. fig. 4. 1257—'69.

Sapphire. Straw yellow at the ends, and pale grey in the middle, oval oblong; $\frac{1}{2}$ in. by $\frac{3}{8}$ in. and $\frac{3}{8}$ in. thick; coronet mount. (Hope catalogue, p. 40, No. 13.) Plate I. fig. 5. 1256—'69.

Sapphire. Yellow, faceted, oval, $\frac{3}{8}$ in. by $\frac{1}{2}$ in.; coronet mount. 1312—'69.

Sapphire. Apricot colour, octagonal oblong, step-cut; $\frac{7}{16}$ in. by $\frac{5}{16}$ in.; bordered with 34 roses, openwork mount. (Hope catalogue, p. 36, No. 13.) Plate I. fig. 6. 1260—'69.

Sapphire. Pale lavender blue, *en cabochon*, prismatic by reason of a flaw, long oval; $\frac{13}{24}$ in. by $\frac{3}{8}$ in.; coronet mount. (Hope catalogue, p. 42, No. 31.) Plate I. fig. 7. 1238—'69.

Sapphire. Deep blue, oblong; $\frac{5}{12}$ in. by $\frac{5}{16}$ in.; with 3 brilliants on each shoulder of the ring, and 4 small roses on the claws of the setting. 1239—'69.

Sapphire. Deep blue, nearly circular; $\frac{7}{16}$ in. diam.; with 2 pear-shaped brilliants ($\frac{1}{8}$ in. by $\frac{1}{4}$ in.) on the shoulders, and 10 small brilliants in the setting. 1240—'69.

Sapphire. Blue, *en cabochon*, oval; $\frac{9}{16}$ in. by $\frac{7}{16}$ in.; claw mounts. 1241—'69.

Sapphire. Blue, faceted, egg-shaped; $\frac{3}{4}$ in. by $\frac{1}{2}$ in. and $\frac{9}{16}$ in. thick; coronet mount. 1242—'69.

Star Sapphire. Pale grey blue, *en cabochon*, oval, $\frac{1}{2}$ in. by $\frac{9}{16}$ in.; plain mount. 1243—'69.

Star Sapphire. Blue octagonal, *en cabochon*; $\frac{25}{32}$ in. by $\frac{21}{32}$ in.; bordered with 47 small brilliants and a socket for another; in silver setting on openwork mount. 1244—'69.

Star Sapphire. Pale blue, hemispherical; $\frac{1}{2}$ in. diam.; bordered with 2 circles of diamonds (26 + 24), and with 27 diamonds on each shoulder of the ring. 1245—'69.

Star Sapphire. Pale blue, squarish, with corners rounded; $\frac{9}{16}$ in. diam.; coronet mount. 1246—'69.

Sapphire. Violet or amethystine—the oriental amethyst; facted, oval; $\frac{7}{16}$ in. by $\frac{3}{8}$ in.; bordered with 24 roses set in silver, and bearing 6 brilliants and 2 roses on each shoulder. (Hope catalogue, p. 39, No. 10.) Plate I. fig. 8. 1247—'69.

Sapphire. Violet or amethystine—the oriental amethyst, faceted, oblong; $\frac{11}{24}$ in. by $\frac{1}{3}$ in.; bordered by 44 roses set in silver on openwork mount. 1277—'69.

Sapphire. Lavender, faceted, oblong; $\frac{5}{12}$ in. by $\frac{3}{8}$ in.; coronet mount. 1248—'69.

Ruby. Pale claret colour, faceted, oblong; $\frac{1}{2}$ in. by $\frac{9}{32}$ in.; coronet mount. 1280—'69.

Ruby. Fine red, faceted; $\frac{1}{4}$ in. by $\frac{3}{16}$ in.; bordered with 12 brilliants; solid mount. 1249—'69.

Ruby. Rich red, Indian polished, subovate; $\frac{3}{8} \times \frac{1}{4}$ in.; set with 2 brilliants and 10 small roses; coronet mount. 1252—'69.

Ruby. Rich red, faceted, oblong, with corners rounded; $\frac{1}{2}$ in. by $\frac{7}{16}$ in.; bordered with 22 brilliants and 2 roses; openwork mount. 1253—'69.

Ruby. Red, faceted, with rounded ends; $\frac{7}{16}$ in. by $\frac{5}{16}$ in. (flaw at one corner); with 14 + 8 brilliants and 2 roses as border, and on shank openwork mount. 1254—'69.

Ruby. Rich red, faceted, circular; $\frac{5}{16}$ in. diam.; with 12 + 6 brilliants and 2 roses on edge and shank; openwork mount. 1255—'69.

Star Ruby. Pink, *en cabochon*, hemispherical; $\frac{13}{16}$ in. diam.; claw mount. 1250—'69.

Star Ruby. Rich colour, *en cabochon*, oval; $\frac{13}{24}$ in. by $\frac{1}{2}$ in.; bordered with 35 brilliants; openwork mount. (Hope catalogue, p. 34, No. 14.) Plate I. fig. 9. 1251—'69.

Corundum. Translucent clove brown, with grey chatoyancy, and with iridescence through a flaw; *en cabochon*, oval; $\frac{2}{3}$ in. by $\frac{7}{12}$ in.; coronet mount. (Hope catalogue, p. 42, No. 27.) Plate I. fig. 10. 1258—'69.

Corundum. Translucent, wine coloured, *en cabochon*, oval; $\frac{3}{8}$ in. by $\frac{5}{16}$ in.; bordered with 16 roses set in silver on a swing mount. (Hope catalogue p. 37, No. 15). Plate I. fig. 11. 1259—'69.

See also Appendix facing page 158.

Spinel.

No precious stone includes so wide a range of colours as the spinel. Following the order of the rainbow, we have red, orange, green, blue, and violet-coloured spinels; and also those which show the hues known as purple, puce, and indigo. Yellow spinels are not unknown; some

are colourless, others black. Another character of importance which enhances the position of the spinel as a gem-stone is its hardness, which, though inferior to that of the ruby, is greater than that of the red garnet. But over against these excellences of the spinel must be set the lack of fire, due to its small refractive and dispersive power; and also the somewhat prosaic quality of its colour, attributable in part to the absence of pleochroism. It is, perhaps, unfortunate for the appreciation of this species of precious stone that its red varieties seem to enter into competition with the incomparable splendour of the ruby, and its blue varieties with the velvety softness of the sapphire. But the spinel owns other hues which labour under no such disadvantages. There is a brilliant aurora red, and a whole suite of passage hues, between indigo and puce, which stand alone for curious beauty. And to these may be added steel-grey, slate and sky-blue, without exhausting the colours offered by the spinel.

The red varieties of the spinel are generally spoken of as "spinel ruby" and "balas ruby;" those designated by the latter name being inferior in colour and brilliancy, and less like the true ruby; but, chemically and physically, there is no sharp distinction between them. "Rubicelle" is a term applied to orange and flame-coloured spinels; those that are violet and purple being called "almandine" spinels.

Spinels fit for use in jewellery come from many localities. Of these the chief are in Burma, Siam, and Ceylon; also in the United States, in New York, and New Jersey, but the fine large red spinels come exclusively from India; several of these, weighing, when properly cut, as much as 25, 72, 81 carats, have recently found

their way to Europe. One rose-coloured specimen weighed as much as 150 carats, but being too pale was sold for no more than £80. An unusually large and fine crimson spinel or spinel-ruby, weighing $49\frac{7}{8}$ carats, from India, proved to have the specific gravity 3·582, while its index of refraction was—for the red ray 1·711, for the yellow ray 1·714, and for the blue ray 1·719. Its hardness scarcely exceeded that of the red garnet, but the tests of specific gravity and refraction sufficed to show that it was a true spinel. A spinel-ruby of rich colour is seen probably to the best advantage when step-cut; the paler hues often look well brilliant-cut. A border of small diamonds enhances the colour and beauty of a spinel.

The spinel crystallizes in the cubic or monometric system, a regular octahedron being its most common form. Some of the natural crystals of spinel are so perfect in shape and polish that they are quite fit for ornamental mounting without further preparation. The hardness of this gem is 8, while its specific gravity is about 3·65. The following determinations of the specific gravity of choice cut specimens of spinel will be useful for reference:

Deep red	3·582	Rose-red	3·631
Aurora-red	3·590	Dull purple	3·637
Puce	3·592	Indigo	3·675
Sky-blue	3·615	Deep indigo	3·715

Where the specific gravity of a spinel is too near that of a garnet to allow of the species being thus distinguished, the superior hardness of the spinel enables the problem to be solved. It is scarcely necessary to say that the dichroiscope affords no criterion in such a case, since the spinel and garnet both belong to the monometric system and are necessarily monochroic.

Spinel is essentially composed of one molecule of alumina and one of magnesia, or in 100 parts:

Alumina	..	..	72	Magnesia	..	..	28

But in the coloured varieties decided traces of other oxides occur, such as those of chromium and iron in the spinel ruby; oxide of copper in the grass-green spinel chlorospinel; and the protoxide of iron in the darker and opaque varieties. Some specimens of pleonaste, the black spinel of Ceylon, have been found to contain over 20 per cent. of ferrous oxide, the protoxide of iron which takes the place of its equivalent of magnesia.

Spinels in true crystals and very hard have been formed artificially, though not of fine quality and large size, by several different processes, such as heating alumina, magnesia, and boracic acid together to a very high temperature. The vapour of aluminium chloride passed over heated magnesia also produces spinel crystals; so does the strong heating together of magnesia and alumina. Some imitation blue spinels or sapphires have been made by the fusion together of alumina, lime, and a little cobalt. These ingredients have, however, given a blue glassy mass softer than true spinel, and merely enclosing here and there a few minute crystals of what may be termed a "lime spinel," the main mass being indeed the same substance, but in a vitreous or non-crystalline state. The specific gravity of this lime spinel, which has been sold for blue sapphire, is lower than that of sapphire or even than that of blue spinel.

Spinel is represented in the Townshend Collection by four specimens:

Spinel. Ruby red, faceted; $\frac{7}{16}$ in. by $\frac{3}{8}$ in.; surrounded on edge and shank by 14 + 8 brilliants + 14 + 31 roses—altogether 67 diamonds; openwork mount. 1326—'69.

Spinel. Ruby red, square, step-cut; $\frac{5}{8}$ in.; surrounded on edge and shank by 20 + 16 = 36 brilliants; set lozenge-wise on a plain mount. 1327—'69.

Spinel. Pale purple, faceted, back step-cut; $\frac{1}{2}$ in. by $\frac{1}{4}$ in; bordered with 37 rose diamonds in openwork mount. 1192—'69.

Spinel. Indigo blue, faceted; $\frac{3}{8}$ in. by $\frac{5}{16}$ in.; bordered with 18 rose diamonds, set in silver on openwork mount. 1325—'69.

TURQUOISE.

The turquoise acquired its name from having been imported into Western Europe by way of Turkey. The best specimens come from the district of Nishapur, in the Persian province of Khorassan, where the gem occurs in a porphyritic rock. The hardness of the stone is nearly 6, and its specific gravity 2·75. There is a peculiar quality in the colour of the best turquoises, which is partly dependent upon the delicate hue of its blue, with which a slight infusion of green is mingled, and partly upon the faint translucency of the stone. For turquoise is indeed not opaque, thin splinters transmitting light easily.

It is very probable that turquoise was described by Pliny under the three names of *callais*, *callaina*, and *callaica*. Turquoise is often now called callaite, while an allied mineral from a Celtic grave near Mané-er H'roek in Lockmariaquer, and now preserved in the Museum of the Polymathic Society of Morbihan, has been called callais and callainite, but has lately been proved identical with the variscite of Breithaupt, a mineral described in 1837.

The true turquoise, which shows various hues and tones of blue, greenish blue, and bluish green, is not to be

confounded with the blue fossil turquoise, or odontolite, which is in fact fossil ivory, generally of Mastodon teeth. The true turquoise owes its colour to phosphate of copper and its powder becomes dark blue when moistened with strong ammonia. Odontolite is coloured by phosphate of iron, is more opaque and heavier than turquoise, and much softer, and shows its bony structure under the microscope. Turquoise often becomes green by age; this change is frequently noticeable in the turquoise cameos of the Italian cinque-cento.

Turquoise is a phosphate and hydrate of alumina, associated with a hydrated phosphate of copper; it always contains small quantities of phosphate of iron and manganese. A fine Persian specimen contained in 100 parts:

Phosphorus pentoxide	32·8	Water	19·3
Alumina	40·2	Copper oxide ..	5·3
Iron and manganese oxides ..	2·4		

Turquoises of considerable size and occasionally of good colour are met with having Persian and Arabic inscriptions or ornamental designs engraved upon them. The hollows of the designs are sometimes gilt, sometimes inlaid with gold wires.

The distinction between turquoises *de la vieille roche* and those *de la nouvelle roche* has a real existence. The former, chiefly obtained from the Nishapur district, are superior in quality of colour, even when the latter belong to the same species, and are not, as is often the case, identical with odontolite, or bone turquoise, or with variscite.

The turquoises from New Mexico vary much in colour; and if originally of a fine blue do not invariably preserve their hue. Some of them contain interspersed particles of

quartz. No less than 7 per cent. of copper oxide occurs in some of the stones from the Burro Mounts, Grant County.

Turquoise is represented in the Townshend Collection by six specimens:

Turquoise. Greenish blue, cut with a female head in relief, nearly circular; $\frac{5}{12}$ in. diam.; solid mount. (Hope catalogue, p. 91, No. 7.) Plate I. fig 12. 1261—'69.

Turquoise. Dark rich blue, somewhat mottled and dull, oval, cut *en cabochon*; $\frac{1}{2}$ in. by $\frac{3}{8}$ in.; bordered with 14 rose-cut diamonds, each in a little floret, and with an outer oval of 14 brilliant-cut diamonds, 3 brilliants on each shoulder of the openwork ring—altogether 34 diamonds. 1262—'69.

Turquoise. Blue, somewhat earthy, oval, cut *en cabochon*; $\frac{1}{3}$ in. by $\frac{1}{4}$ in.; bordered with 14 brilliants; openwork mount. 1263—'69.

Turquoise. Fine blue, oval, cut *en cabochon*; $\frac{5}{12}$ in. by $\frac{7}{24}$ in.; broad and thick gold ring. 1264—'69.

Turquoise. Deep blue, oval, nearly flat; $\frac{1}{2}$ in. by $\frac{3}{8}$ in.; solid mount. 1265—'69.

Turquoise. Rather pale and somewhat greenish blue, heart-shaped, inlaid with gold wires; Persian; $\frac{3}{4}$ in. by $\frac{1}{2}$ in.; coronet mount. 1266—'69.

Callainite.

There are three minerals passing under the name of turquoise. The true turquoise is the callaite of mineralogists; then there is a fossil turquoise or odontolite; and lastly we have a pale bluish-green stone which has been described under the names callais, variscite, and

callainite, and which presents a near relationship to the true turquoise. Its hardness is 4; its specific gravity 2·55; and its percentage composition:

Alumina	32·4	Phosphorus pentoxide	44·9
Water	22·7		

There is another blue mineral related chemically to turquoise and callainite and known as lazulite. It is essentially a hydrated phosphate, but contains besides aluminium, a considerable proportion of magnesium and iron; copper is generally absent. It is softer and rather heavier than turquoise, and is far more difficult to dissolve in acids than that species. In colour it varies from a fine sky-blue to a tint not far removed from that of pale lapis-lazuli—a perfectly distinct mineral. Lazulite was occasionally used in ancient times as an inlay, for instance, in the gold armlet from the Oxus now preserved in the British Museum.

TOPAZ.

Although the topaz is a perfectly definite and distinct mineral species, yet three different stones are commonly called by this name. But the topaz known as "oriental topaz" is in reality the yellow sapphire, a kind of corundum; the occidental or Scotch topaz is nothing but yellow quartz; while the true topaz, sometimes spoken of as the Brazilian topaz, is the only one which in reality may properly bear the name. The hardness and specific gravity of these three stones are very different, and furnish good criteria for their discrimination:

	Hardness.	Specific Gravity.
Oriental topaz	9	4·01
Brazilian ,,	8	3·53
Scotch ,,	7	2·65

The true topaz belongs to the orthorhombic system; its crystals are prisms, usually having but one end regularly terminated. The cleavage of topaz is highly perfect and basal, that is, transverse to the length of the prism. The prismatic faces are commonly deeply channelled but brilliant. The refractive indices of topaz, in the three directions of the axes, are, for the yellow ray in a colourless crystal:

$$\alpha = 1{\cdot}622;\ \beta = 1{\cdot}615;\ \gamma = 1{\cdot}612.$$

The double refraction of topaz is strong, and the pleochroism of coloured specimens very marked. A wine-yellow crystal from Brazil showed two images, one rose pink and the other brownish yellow, in the dichroiscope; after heating, the same crystal gave a stronger pink colour and a dull white. The colours of topaz are many and beautiful; the rose pink (often called burnt topaz) is commonly obtained by heating the richly coloured wine-yellow or amber-yellow crystals, but occasionally occurs in natural specimens. Blue and pale green topazes are sometimes found of large size, and are more brilliant than similarly tinted beryls. Colourless topazes vary a good deal in purity of hue and fire; those from Brazil are often of remarkable whiteness, and show dazzling reflections of pure white light when properly cut. The polish which the topaz takes is very high, and the surface of cut specimens is exceedingly smooth and slippery to the touch.

The specific gravity of the topaz, even in perfectly flawless and transparent specimens, ranges between rather wide limits, so far as the colourless specimens from different

localities are concerned. The coloured specimens show a much smaller variation.

Topaz, white ..	3·597	Topaz, rose pink ..	3·534
" " ..	3·595	" " ..	3·533
" " ..	3·585	" sherry yellow	3·539
" " ..	3·572	" blue	3·541

The topaz is one of the few precious stones containing the element fluorine; it may be regarded as a silicate of alumina, in which part of the oxygen of the silica is replaced by fluorine. The analysis of topazes from different localities points to a composition which may be represented in 100 parts by these figures:

Silicon	15·5	Oxygen	36·8
Aluminium	30·2	Fluorine	17·5

A little water is always present in topaz; it is probable that the hydroxyl of this replaces a part of the fluorine. Such replacement helps to account for slight differences in the physical characters of topaz from different localities. When strongly heated, topaz not only changes in colour, but loses considerably in weight; hydrofluoric acid, fluoride of silicon, and fluoride of aluminium being given off to the extent of 20 to 24 per cent. With moderate heating no loss of weight, but merely change of colour, occurs, the bulk of the stone remaining unaltered, and consequently its specific gravity suffering no increase or diminution. The sherry-coloured, the brown, and the other tinted topazes, which are susceptible of being "pinked" by heat, exhibit a very curious phenomenon during the operation. When a suitable stone is packed in magnesia or other inert material, and heated in a crucible, the specimen, if removed before it is cold and laid upon a white surface, shows scarcely any trace of colour; but

after a little time, when the stone has acquired the temperature of the air, the desired pink hue makes its appearance. If the temperature reached has not been sufficiently high, a salmon tint, or a hue like that of a drop of blood mingled with much water, is obtained instead of a rose-petal pink. What the cause of these changes of colour is remains doubtful: it may be a change in the molecular or physical condition of some minute trace of a coloured constituent in the topaz, or it may be an actual chemical change. Anyhow, the colour of topaz is a very unstable one, for light, or at least the solar rays, soon exerts a bleaching effect on many pale-coloured specimens; so that the fine suite of wine-hued Russian crystals, collected by Colonel de Kokscharow, and now in the British (Natural History) Museum, is kept shrouded from the light of day.

Topaz occurs in several Scotch and Irish, and in some English, localities—St. Michael's Mount in Cornwall, may be named amongst the latter. Villa Rica, Minas Novas in Minas Geraes in Brazil, Flinders Island, and many places in the United States, as well as several Siberian localities, furnish splendid specimens of colourless and coloured topaz. The white topazes from Flinders Island are less brilliant than those from Brazil. Good topazes come from Pegu and Ceylon, and they have been found in Australasia. A magnificent deep blue topaz was found in Ceylon in 1899: when cut it weighed no less than 355 carats. The *topazios* of the ancients was our chrysolite and peridot, not the stone now called topaz, which was not known as a distinct stone until comparatively modern times. The topaz (*pitdah*) of Aaron's breastplate was probably a peridot.

The commercial value of the topaz is small and variable. Very richly-coloured specimen stones, suitable for pendants, may be bought for a pound or a few pounds; they are often sold by the ounce, not by the carat.

Topaz is represented in the Townshend Collection by eleven specimens:

Topaz. Colourless, brilliant-cut, nearly square, rounded corners; $\frac{7}{12}$ in. diam.; coronet mount. 1308—'69.

Topaz. Sherry yellow, faceted oval; $\frac{13}{16}$ in. by $\frac{5}{8}$ in.; bordered with 36 diamonds set in silver on an openwork mount. 1310—'69.

Topaz. Yellow, faceted oblong; $1\frac{1}{4}$ in. by $\frac{2}{3}$ in., and $\frac{5}{12}$ in. thick; coronet mount. (Hope catalogue, p. 65, No. 5.) Plate I. fig. 13. 1311—'69.

Topaz. Rich yellow, faceted oblong, with slightly convex sides; $1\frac{1}{12}$ in. by $\frac{11}{12}$ in., and $\frac{7}{12}$ in. thick; coronet mount. 1313—'69.

Topaz. Yellow, with flaws along cleavage planes, step-cut, octagonal oblong; $\frac{9}{16}$ in. by $\frac{3}{8}$ in.; solid mount, with four claws. 1314—'69.

Topaz. Light brown, brilliant-cut; $\frac{1}{2}$ in. by $\frac{3}{8}$ in.; coronet mount. 1315—'69.

Topaz. Deep wine yellow, faceted oval; $\frac{11}{12}$ in. by $\frac{2}{3}$ in., and $\frac{5}{12}$ in. thick; coronet mount. 1195—'69.

Topaz. Rose pink, faceted oblong; $\frac{5}{8}$ in. by $\frac{11}{24}$ in.; coronet mount. 1188—'69.

Topaz. Deep rose pink or light claret, faceted oblong; $\frac{5}{8}$ in. by $\frac{13}{24}$ in.; bordered by 34 roses set in silver on openwork mount. (Hope catalogue, p. 67, No. 16.) Plate I. fig. 14. 1309—'69.

Topaz. Pink, oblong; $\frac{5}{8}$ in. by $\frac{1}{2}$ in.; bordered by 36 roses set in silver on openwork mount. 1317—'69.

Topaz. Sea blue, faceted oval; $\frac{3}{4}$ in. by $\frac{5}{8}$ in., and $\frac{11}{24}$ in. thick; coronet mount. 1316—'69.

TOURMALINE.

The tourmaline is marked out from all other precious stones by a very complex chemical constitution, and by a very interesting optical structure. Its hardness, 7·3 to 7·5, suffices to protect it from wear, while the range and quality of the colours which it exhibits commend it to those persons who appreciate the artistic value of jewellery in which other stones besides those which are well-known and popular form dominant elements.

All the minerals called by the names "indicolite" (blue), "rubellite" (red), "schorl" (black), and "achroite" (colourless) form but one species—tourmaline. These differences of colour are accompanied by differences of composition, so that we have a series of varieties of tourmaline, in which, while the proportion of silica is fairly constant, the bases consist of the oxides of iron, magnesium, sodium, manganese, and aluminium in differing proportions. Water is also present, and sometimes lithia and potash. To give some notion of the chemical complexity of the tourmaline we may cite an analysis by Rammelsberg of a green Brazilian stone of specific gravity 3·107:

	In 100 parts.		In 100 parts.
Silica	38·55	Lime	1·14
Alumina	38·40	Soda	2·37
Manganic oxide	·81	Lithia	1·20
Ferric ,,	5·13	Potash	·37
Ferrous ,,	2·00	Boron trioxide	7·21
Magnesia	·73	Fluorine	2·09

The specific gravity of tourmalines varies between 3 and 3·25. The following determinations were made with particular care:

Tourmaline, almandine coloured	3·009
" rich rose pink	3·044
" orange-brown, from Ceylon	3·082
" lemon-yellow	3·106
" green, from Brazil	3·109
" black, Bovey Tracey, Devon	3·120
" green, from Brazil	3·154

The tourmaline occurs crystallized in the form of prisms belonging to the rhombohedral system; some of the faces are striated or even channelled. The hardness of perfectly flawless transparent tourmalines is from 7·3 up to 7·5.

The optical properties of tourmaline are most striking. When a crystal is viewed along the direction of its principal axis, it is less transparent and of a different colour than when viewed across that axis. The coloured varieties, or most of them, absorb and quench to different degrees the ordinary ray, which is polarized in a plane parallel to the axis, while they allow the extraordinary ray, polarized in a plane perpendicular to this line, to pass. Examples of the marked dichroism, which is so conspicuous a feature in the majority of coloured tourmalines, may be seen in this list of twin colours of the two polarized rays passing along and across the crystal respectively:

ORDINARY RAY.	EXTRAORDINARY RAY.
Yellow brown.	Asparagus green.
Deep violet brown.	Greenish blue.
Purple.	Blue.

The following are some additional instances of the twin colours seen in tourmalines, owing to the optical peculiarity just named. These examples were observed

with the aid of the dichroiscope which serves for the study of such a phenomenon admirably, causing as it does, a complete separation of the oppositely-polarized and differently-coloured rays, not attainable by mere inspection of a polished slice of a tourmaline crystal :

COLOUR OF STONE.	TWIN COLOURS.
Red	Salmon—Rose pink.
Brownish red	Columbine red—Umber brown.
Brown	Orange brown—Greenish yellow.
Green	Pistachio green—Bluish green.

A few illustrations of the influence of this powerful dichroism upon the appearance of cut and faceted tourmalines will be of service, not merely in identifying doubtful specimens, but in explaining the peculiar and exquisite quality of the colours which this gem-stone shows. If we cut a green tourmaline in such a manner that the table and culet are perpendicular to the axis of the crystal, the probability is that the gem will appear, especially in its thicker parts, perfectly opaque and black. Held sideways we may see some greenish and olive green hues, by looking across the stone from one part of the girdle to another. Now the same green tourmaline may be so cut as to present a brilliant appearance with a fine play and interchange of two hues of green, by making the table parallel with the axis. If the crystal be a yellowish brown one, a very beautiful effect is secured by cutting it in the form of a brilliant, but with a small table parallel with the axis. The templets and other facets of the crown should be well developed so as to display, as the stone is viewed in different positions, the

different colours of the light transmitted and reflected in different directions which become visible in one after another of the facets. If one of these be at one moment greenish yellow, presently it is yellowish brown, and then russet.* With pale yellowish and greenish grey tourmalines cut in a similar manner, there will be seen other and equally striking changes of hue.

In the table on page 96 several localities of tourmaline are given. Of these some yield crystals, which are particoloured, perhaps having a rosy central position enclosed in a green shell. Recently many fine tourmalines have reached this country from the Mount Bity district of Madagascar, from Minas Geraes in Brazil, and from several localities in California, such as Pala, Mesa Grande and Romona. The brightness and the wide range in colour of many of these stones, especially of those from some of the Californian localities, has made the tourmaline more popular as a gem-stone during the last few years.

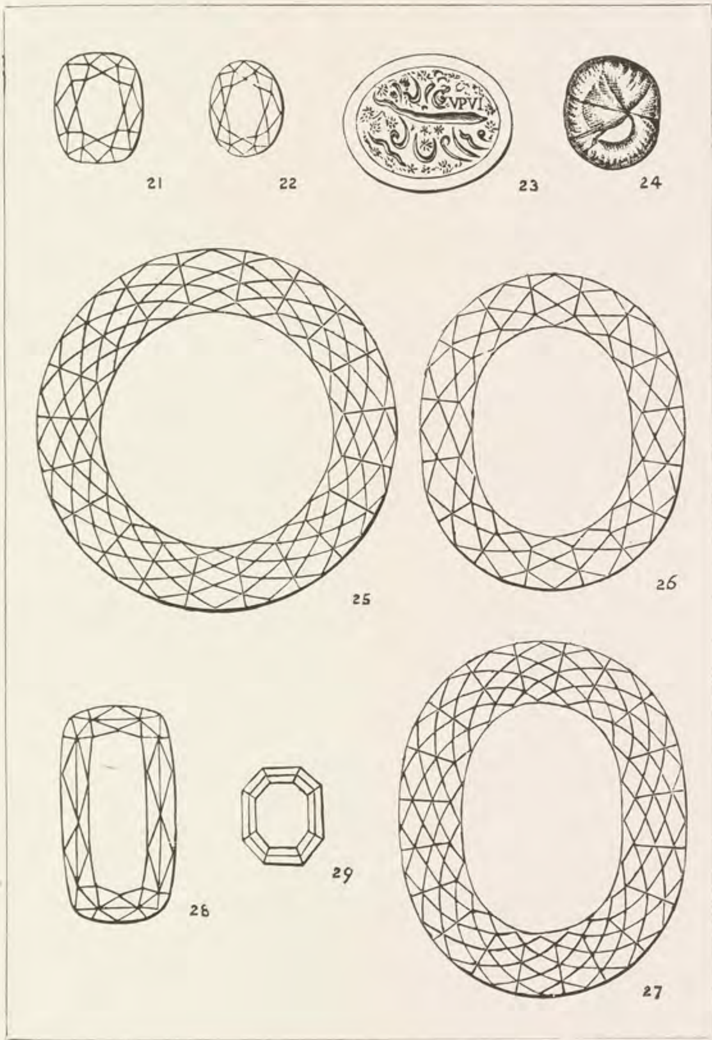
When a tourmaline is rubbed, or, better still, when it is heated, it becomes electrically charged. The polarity of the charge is beautifully shown when a mixture of red lead and sulphur in powder is allowed to fall from a muslin sieve upon a tourmaline crystal when in process of cooling. The red lead will gather about the negatively electrified end, the sulphur about that which is positively electrified.

Tourmaline is represented in the Townshend Collection by six specimens:

Tourmaline. Rubellite, cloudy red, rose cut, flat at back; ¾ in. diam.; coronet mount. (Hope catalogue, p. 72, No. 27.) Plate I. fig. 15. 1320—'69.

* Frontispiece, Figs. 6 and 8.

Plate II.—Garnets, Beryls.



To face page 98.

Tourmaline. Rich brown, faceted; $\frac{19}{24}$ in. by $\frac{7}{12}$ in.; coronet mount. (Hope catalogue, p. 71, No. 19.) Plate I. fig. 16. 1275—'69.

Tourmaline. Deep green, oblong faceted; $\frac{13}{24}$ in. by $\frac{5}{12}$ in.; coronet mount. (Hope catalogue, p. 52, No. 2). Plate I. fig. 17. 1321—'69.

Tourmaline. Deep green, oblong table, with step-cut bezel, back step cut; 1 in. by $\frac{3}{4}$ in. and $\frac{5}{12}$ in. thick; coronet mount. (Hope catalogue, p. 70, No. 3.) Pl. I. fig. 18. 1323—'69.

Tourmaline. Indicolite, indigo blue, oval faceted; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; coronet mount. 1319—'69.

Tourmaline. Nearly black, large table, faceted, almost square; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; coronet mount. 1294—'69.

See also Appendix facing page 158.

Garnet.

The great group of the garnets includes several gem-stones which would not be included under a single name, as having many characters in common, were it not that chemical and crystallographic properties must be allowed to overbalance the more obvious peculiarities of these minerals. Garnets present almost all hues and tones of colour save those in which blue predominates, while they vary greatly in hardness and specific gravity. But the crystalline forms in which they occur are all referable to this same system, the cubic or monometric, while the chemical expression which represents their constitution is identical in structure, though one or another constituent be replaced by analogous elements. All garnets are normally singly refractive and monochroic; where double

refraction is observed it is due to internal stresses. The following list includes the chief varieties of garnet:—

1. Cinnamon-stone or Hessonite—Calcium aluminium garnet.
2. Almandine and Carbuncle—Ferrous aluminium garnet.
3. Pyrope or Bohemian garnet—Ferrous magnesium calcium aluminium garnet.
4. Spessartite or Manganese garnet—Manganous aluminium garnet.
5. Rhodolite—Ferrous magnesium aluminium garnet.
6. Demantoid or Bobrovka garnet—Calcium ferric garnet.
7. Uvarovite—Calcium chromium garnet.

Besides the bases indicated in the above list as characteristic of the several kinds of garnet there are in all of them minor constituents as to which a few words are required. Amongst these special mention must be made of chromium sesquioxide, to which the emerald hue of some demantoid has been attributed and which is also found in much pyrope. Traces of other oxides likewise occur in several of the remaining varieties. So also in those garnets in which iron is a large and essential constituent, this metal is found to exist, at least generally, in two states of oxidation, indicated by the terms ferrous for the protoxide and ferric for the sesquioxide. Thus, almandine, along with 32 or 33 per cent. of ferrous oxide, generally contains 2 or 3 per cent. of ferric oxide, while in demantoid a little ferrous oxide is associated with about 30 per cent. of ferric oxide. Then, too, manganous oxide, which is the chief protoxide in spessartite, occurs in small proportion in all or nearly all the remaining varieties of garnet. These and other minor peculiarities of composition are all covered by the chemical expression of "garnet formula." This formula contains three molecules of silica (SiO_2) combined with one molecule of a sesquioxide such as Fe_2O_3, Al_2O_3 or Cr_2O_3 and with three molecules of a monoxide, such as FeO, MnO, CaO, or

MgO. If any of the above sesquioxides be represented by the formula R_2O_3 and the above monoxides by MO, then the general expression for garnet becomes R_2O_3, 3MO, $3SiO_2$. One character common to all garnets save uvarovite is their fusibility before the blow-pipe; they thus yield a vitreous mass which is of much lower density than that of the original garnet before fusion. As the members of the garnet group differ so widely from each other in appearance, hardness, specific gravity, etc., it will be advisable to discuss the several varieties used in jewellery separately.

1. Cinnamon stone or Hessonite. — This garnet (generally, but incorrectly, called essonite) has long been confused with zircon of similar colour—a sort of deep golden hue with a tinge of flame red. All the engraved gems said to be of hyacinth and jacinth—that is, zircon—are in fact cinnamon stones, or, as they may be called, hyacinthine garnets, not zircons; we except those which, while resembling cinnamon stone, are only sard. The three species may be discriminated in several ways, the true hyacinthine zircon having, for example, the specific gravity of 4·6, the cinnamon stone 3·7, and the sard 2·66: other criteria are furnished by differences in lustre, hardness, and refractivity. The best hessonites come from Ceylon: they may be recognized by their peculiar appearance, in a good light, when examined by the aid of a hand magnifier. This appearance is that of a finely granulated texture, as if made up of sand grains barely molten together. The specific gravity of cinnamon stone will be seen from the following determinations to be fairly constant:—(1) 3·69. (2) 3·657. (3) 3·642. (4) 3·642. (5) 3·666. Grossularite belongs here.

A cinnamon stone from Ceylon gave on analysis these percentages:—

Silica	40·0	Iron oxides	3·4
Alumina	23·0	Manganous oxide	0·6
Lime	30·6	Other substances	2·4

Antique Roman intaglios on cinnamon stone, both light and dark in tone, are numerous; cameos are not infrequent. This stone is more easily cut and engraved than the full red varieties of garnet, having indeed a degree of hardness very near that of quartz, instead of quite half a degree above it.

2. Almandine, carbuncle, precious garnet.—The range of colour in this variety of garnet lies between a violet or purple near that of the amethyst and a brownish red or reddish brown. The pure fiery scarlet specimens, the deep red, and the crimson are commonly cut *en cabochon*, with a hollow at the back to receive a bit of foil; such stones are called carbuncles. A delicate silvery cross is seen in some carbuncles, which may be called star carbuncles; this star has but four rays instead of the six belonging to the star sapphire. The garnets of this variety generally show a very distinctive set of three black bands when viewed with the spectroscope.* This peculiarity was discovered by the present writer and published in the "Intellectual Observer" of 1866. This group of absorption bands may be made to serve as a criterion for discriminating between the red garnets of this variety and red spinels. When a red garnet is faceted, the table should not be large nor the stone be left very thick or a blackish appearance will result. The almandine is said to

* Frontispiece, Fig. 10.

have arisen from Pliny's adjective *alabandicus*, applied to the *carbunculus* cut and polished in the town of Alabanda, in Asia Minor. Syriam, once the capital of the ancient kingdom of Pegu, was, it appears, an important mart for fine almandines, hence the term Syriam or Syrian garnets was applied to the choicer specimens of almandine. Besides the old and numerous Indian localities of almandine, Brazil, South Australia and German East Africa furnish fine specimens.

Transparent red garnets of very large size have been fashioned into cups and boxes. Slabs of polished garnet, sometimes of considerable area, were employed as inlays in Celtic and Anglo-Saxon jewellery.

The red or precious garnets of the variety under discussion are never found with the exact theoretical composition of a pure "ferrous aluminium" garnet; there is always some admixture or replacement. But a characteristic specimen was found to contain, in 100 parts, about—

Silica	39	Manganous oxide	1
Alumina	19	Magnesia	2
Iron oxides	37	Lime	1

Nearly all the iron was in the form of ferrous oxide. The hardness of this variety of garnet is about 7·5, while its specific gravity is seldom less than 4·1 and may be as high as 4·3; its refractive index ranges about 1·79.

3. Pyrope or Bohemian Garnet.—The pyrope is essentially a magnesium iron aluminium garnet, but variable, and sometimes not inconsiderable, quantities of other metals are present, so that this variety of garnet must be regarded as belonging to a mixed type. Its colour is usually blood-red, or deep red with some orange. It is

usually perfectly flawless and transparent, and, when of any size, may appear of so dark a colour as to be almost black. It is this blackness which is the chief distinguishing feature between a blood-red pyrope and a blood-red ruby, though the superior lustre, fire and dichroism of the latter gem afford other criteria in the discrimination of the two stones. Moreover, in hardness and in specific gravity the pyrope is inferior to the ruby. This stone, which is found in great abundance, though of small size, in many places in Bohemia, is usually rose-cut and often foiled. Specimens from other localities, such as those from South Africa (often wrongly called Cape rubies), are not infrequently brilliant-cut. The hardness of pyrope lies between $7\frac{1}{4}$ and $7\frac{1}{2}$; its density is just below 3·8, on the average about 3·75. It is less easily fused than any other garnet save uvarovite; its refractive index is about 1·76.

Three analyses of pyrope are here given, as it is well to have this means of comparing the percentage composition of this garnet from different localities, and its divergence from almandine:

	Bohemia.	New Mexico.	S. Africa.
Silica..	41·4	42·1	41·0
Alumina	22·3	19·3	22·0
Ferrous oxide	9·0	14·0	13·5
Ferric oxide	1·0	1·0	1·5
Manganous oxide	2·0	0·4	0·5
Chromium sesquioxide	3·5	2·6	1·5
Magnesia	15·0	14·0	15·0
Lime	4·7	5·2	5·0

These analyses cannot be discussed here, but this at least may be said concerning them, that they do not accord exactly with the garnet formula, and that the state of oxidation of the three metals, iron, manganese,

and chromium, has not been ascertained with complete accuracy.

Pyrope is well known through the roughly faceted beads cut from this garnet and through the cheap Bohemian jewellery, where it figures as the chief stone. Choice specimens are worthy of better cutting and better settings.

4. Spessartite or Manganese Garnet.—As a rule this variety of garnet does not occur in a sufficiently clear state to allow of gem-stones being cut from it. Some considerable quantities, however, from Amelia Court House, Virginia, U.S.A., have been cut and polished. Some of the very small aurora-red spessartites from Nevada have yielded brilliant gems, but at present the very finest specimens, extremely lustrous and of a magnificent aurora-red or flame-colour, are found in one or two localities in Ceylon. These resemble cinnamon stone and have been sold as very choice specimens of that kind of garnet, but they are incomparably more beautiful. They are easily distinguished from hessonite by their higher specific gravity, which is 4·14 instead of 3·66. A step-cut spessartite from Ceylon in the author's possession weighs 6¾ carats, having lost 2 carats by re-cutting in London, but with a most marked improvement in the appearance of the gem. Very few of these stones have been found; they bring £2 or £3 per carat when of fair size, that is above 2 or 3 carats in weight.

5. Rhodolite.—This beautiful variety of garnet is of a rose-red colour, somewhat verging on purple. It is more brilliant and less deep in tone than almandine and pyrope, while it partakes of the chemical constitution of both of these stones. It shows, though somewhat faintly, the

system of black absorption-bands which is characteristic of almandine. Its specific gravity is 3·84, a figure much nearer that of pyrope than that of almandine. Rhodolite occurs at Cowie's Creek and Mason's Branch in Macon County, N. Carolina, U.S.A. It is quarried and cut to a large extent as a gem-stone.

6. Demantoid or Bobrovka Garnet.—This is a calcium ferric garnet from the Syssersk district on the Western slopes of the Urals. It is softer than any other garnet, but its colour—that of a rather yellowish green emerald —has made it a valuable and popular stone. Unfortunately, dealers and jewellers have given it names to which it has no right. It was called "Uralian emerald" at one time, and now it is generally called olivine, the proper designation of an entirely different stone, namely, the peridot. Demantoid is in reality only one of a number of sub-varieties, having a wide range of colours and of constituents, of calcium ferric garnet, but it is the only one that is appreciated as a precious stone. The most esteemed colour is near that of the emerald, but the yellowish green, the pistachio, asparagus, and olive-green stones, as well as the liver-coloured stones, are not without beauty, owing, doubtless, to the lustre of the polished facets of the gem, and to its high refractive (1·885) and dispersive powers, which impart to it a brilliancy and fire possessed by no other green stone. Demantoid appears to advantage under artificial illumination. Its hardness is about 6°—rather too low for a ring-stone. The specific gravity of three specimens proved to be as follows:

Green-yellow, 3·854; Pistachio-green, 3·848; Emerald green, 3·849. Although demantoid has been frequently analysed, its constitution has not been brought precisely

into line with the garnet formula. It is thought that the emerald green specimens owe their distinctive hue in part to the presence of chromium.

7. Uvarovite, or Calcium Chromium Garnet.—This variety always contains some alumina in place of part of the chromium sesquioxide. It is of a fine emerald green, has the hardness $7{\cdot}5^{\circ}$ and the density $5{\cdot}5$, but it rarely admits of being cut as a gem owing to its occurrence in very small crystals, or its want of complete transparency. Of other garnets mention may be made of black garnets used in the 18th century in mourning jewellery; of the yellow and greenish-yellow garnets known as topazolite, and of colophonite, which resembles common resin: all these are essentially calcium ferric garnet, and with demantoid are included under andradite.

Three varieties of Garnet, namely Pyrope, Almandine and Hessonite, are represented in the Townshend Collection by twelve specimens:

Garnet. Pyrope of blood-red colour, round, rose-cut; $\frac{1}{4}$ in. diam., with border of 9 brilliants set in the broad edge of the plain solid ring. 1269—'69.

Garnet. Seven pyropes of blood-red colour set in a cluster on a plain mount. 1276—'69.

Garnet. Carbuncle cut *en cabochon* and set on foil, oval; $\frac{11}{12}$ in. by $\frac{2}{3}$ in.; solid claw mount. 1270—'69.

Garnet. Almandine, of crimson colour, faceted, nearly circular; $\frac{17}{24}$ in. by $\frac{5}{8}$ in.; coronet mount. (Hope catalogue, p. 61, No. 13.) Plate I. fig. 19. 1271—'69.

Garnet. Almandine, cut *en cabochon*, with hollowed back, engraved with a faun; $\frac{5}{6}$ in. by $\frac{1}{2}$ in.; plain mount. (Hope catalogue, p. 62, No. 24.) Plate I. fig. 20. 1272—'69.

Garnet. Almandine, flat, escutcheon-shaped; $\frac{1}{3}$ in. by $\frac{1}{4}$ in.; claw mount. 1273—'69.

Garnet. Deep red, faceted, octagonal; $\frac{7}{12}$ in. diam.; open-work claw mount. 1273—'69.

Garnet. Brownish red, faceted, oblong; $\frac{13}{24}$ in. by $\frac{5}{12}$ in.; bordered with 47 rose diamonds, set in silver on open-work mount. (Hope catalogue, p. 62, No. 23.) Plate II. fig. 21. 1274—'69.

Garnet. Hessonite, or cinnamon stone, of aurora red hue, faceted; $\frac{7}{8}$ in. by $\frac{23}{32}$ in.; coronet mount. 1279—'69.

Garnet. Hessonite, or cinnamon stone, of aurora red hue, carved in high relief, with a bust; plain mount. 1306—'69.

Garnet. Hessonite, or cinnamon stone, of aurora red hue, oblong; $\frac{3}{8}$ in. by $\frac{1}{3}$ in.; light coronet mount. 1307—'69.

Garnet. Hessonite, or cinnamon stone, of aurora red hue, oblong with rounded corners, faceted; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; coronet mount. (Hope catalogue, p. 53, No. 6.) Plate II. fig. 22. 1318—'69.

See also Appendix facing page 158.

PERIDOT.

Under the species olivine are now included both the yellow and greenish-yellow chrysolite and the pistachio-green or leek-green peridot, or evening emerald. The latter possesses a quieter hue than the emerald, and needs to be in rather large pieces that its colour may be properly developed. Perhaps the peculiar hue of the peridot may be best suggested by that seen on looking through a delicate green leaf. It contains more yellow and grey than the emerald. The peridot is dichroic, giving a straw yellow and a green image.* It crystallizes in the

* Frontispiece, Fig. 4.

orthorhombic system. Its hardness is unfortunately rather low, about 6·5, so that polished specimens are easily scratched by wear. The peridot is, however, well suited for engraving, and forms, when set in black and white, or orange enamel and gold, a beautiful stone for pendants. Engraved peridots are, however, with very few exceptions, of modern date. The specific gravity of the peridot is not changed by heat. A careful determination of the specific gravity of a fine rich-coloured peridot gave 3·389. A range of 3·35 to 3·44 is usually assigned to this variety of the "precious olivine."

Fine peridots come from Egypt, but until quite recently the largest and finest peridots met with in commerce were obtained from old ecclesiastical and other jewellery. Now one at least of the best of the original sources has been re-discovered in the island of St. John in the Red Sea. And still more recently the islands of Rahamah and Kad-Ali appear likely to prove among the best localities for the peridot. A store of fine peridots in the rough has been lately disinterred from the foundations of a house in Alexandria. It is supposed that these stones were buried with the intention of securing good fortune for the building. One of the peculiarities of olivine is its occurrence in meteorites. There are some good peridots in the Townshend collection, and characteristic specimens in the British (Natural History) Museum and in the Museum of Practical Geology.

The percentage composition of peridot, though the ferrous oxide may be more or less replaced by magnesia, is approximately:

Silica	41	Ferrous oxide	9
Magnesia	50		

Manganese, nickel, and lime have been found in small quantities in some olivines.

The term olivine is now wrongly applied by dealers in precious stones and by jewellers to the green garnets or demantoid from Bobrovka; these, for a time at least, were called, with equal incorrectness, Uralian emeralds. A considerable quantity of pale green cut gem-stones has been sold in London as peridot, but on examination proved not to be that variety of chrysolite. They were softer than peridot, and, though more glittering in lustre, were of poorer colour. They were not dichroic and showed no sign of crystalline structure. On analysis they were found to contain much more silica and much less magnesia than peridot, while alumina and soda were present in distinct quantities; if the material had not been known to be a natural product, these specimens would have been called green glass. Their composition varies widely, and so does their density, the latter ranging from 2·36 to 2·63. The mineral which occurs in several Bohemian and Moravian localities is known as water-chrysolite, pseudo-chrysolite, moldavite and *bouteillenstein*. Various opinions are held as to its origin, some mineralogists even going so far as to state it to be an artificial glass from the site of early glass factories. It has also been conjectured that it may be of meteoric origin. Some glass has undoubtedly been sold as moldavite, but the genuine material differs in intimate structure, in fusing point, and in chemical composition from any kind of glass. It is not identical with obsidian, while its occasional occurrence as rolled pebbles in the gem-gravels of Ceylon strengthens the view that there is a moldavite which is a natural product.

Peridot is represented in the Townshend Collection by four specimens:

Peridot. Leaf green, engraved with hermaphrodite, tree, and Greek inscription; nearly circular; $\frac{2}{3}$ in. diameter; plain mount. (Hope catalogue, p. 84, No. 7.) 1300—'69.

Peridot. Leaf green, octagonal oblong, step-cut, $1\frac{1}{4}$ in. by $1\frac{1}{6}$ in.; coronet mount. 1301—'69.

Peridot. Leaf green, rounded oblong, faceted; $\frac{5}{6}$ in. by $\frac{3}{4}$ in. and $\frac{5}{12}$ in. thick; solid mount. 1302—'69.

Peridot. Rich leaf green, table slightly convex, back, barrel-shaped, with faceted ends; $1\frac{1}{4}$ in. by $\frac{11}{12}$ in. and $\frac{2}{3}$ in. thick; coronet mount. 1303—'69.

BERYL.

(EMERALD, AQUAMARINE.)

The emerald and the aquamarine are included by mineralogists under the species beryl. The differences of colour are due to minute traces of compounds too small to be determined with exactitude. The chemical constitution and the crystalline form of all the varieties of the mineral are the same. The form is a regular six-sided prism, belonging to the hexagonal (rhombohedral) system. This prism is often striated, both internally and externally, with delicate lines and fissures which are invariably parallel with its sides, not, as is the case with quartz crystal, at right angles with or across these sides.

The specific gravity of the different varieties of beryl, when free from flaws, cavities, and intruding minerals, is as nearly as possible 2·7. So the emerald and the aquamarine are a little heavier than rock crystal (2·66) and much lighter than green garnets (3·85) or green

sapphires (4). Here are a few determinations of specific gravity made with stones of different colours :

Emerald (from Muzo)	2·710	Blue beryl	2·701
,, ,,	2·704	Yellow beryl	2·697
Aquamarine (Brazil)	2·702	Brown yellow beryl	2·690

The hardness of beryl varies between 7·5 and 8, the fine emeralds of Muzo being less hard than the aquamarines of Brazil and Siberia; they are also rather brittle. The indices of refraction for the green ray in the emerald of Muzo are:

$$\omega = 1{\cdot}584\,;\ \epsilon = 1{\cdot}578.$$

The dichroism of some forms of beryl is very strong; this is particularly the case with the emerald. Viewed across the prism with the dichroiscope the two images of the emerald are seen to be of different hues of green—one verging on yellowish green, and the other being a green with a tinge of blue.* The same effect of hue may be noticed in small parcels of cut emeralds—cut, it may be, from the same stone. And it cannot be doubted that the dichroism of the emerald plays a part in producing its peculiar colour effect. The aquamarine is also dichroic, a sea-green specimen showing straw white and grey blue as twin colours.

The range of colour in the beryl is not very extensive; colourless specimens occur, but usually the palest beryls have a faint greenish or bluish tint. The most usual colours are pale green and pale blue, with intermediate hues. The true deep rich green of the emerald is rare, but pale yellow, honey yellow, and yellow brown beryls are not uncommon. Sometimes this stone occurs with a rose tint.

* Frontispiece, Fig. 3.

The best emeralds occur near Muzo, about ninety-seven miles N.N.W. of Bogotà in the Republic of Colombia, South America. The stones occur in isolated and implanted crystals and in geodes in a calcareous rock in which are very fossiliferous concretions of bituminous character; the emeralds are accompanied by calcspar, gypsum, quartz, pyrites, and parisite. The rock belongs to the Neocomian formation. From this locality and from another known as Somondoco, and situated about half a degree east of Bogotà, it is probable that the fine emeralds secured by the Spaniards in their South American conquests of the 16th century had been originally derived. The really ancient source of emeralds before the discovery of the New World is, however, to be found in Upper Egypt: the mines occur in a depression of the mountainous range which borders the Western Coast of the Red Sea. One group of mines is situated on Mount Sakketto, the other on Mount Sabara. The gems are generally full of flaws and poorer in colour than the fine specimens from Colombia.

Fine beryls occur in the Urals at several localities in the neighbourhood of Ekaterinburg, especially near Mursinska. There are other Siberian localities of importance where good aquamarines are found. In this connection must be named the occurrence of fine stones in several places in the United States of America, in Brazil, and in British India. Beryl, or rather, aquamarine, has been long worked in the District of Coimbatore in the Province of Madras. Fine beryls have recently been found in Madagascar; among these some having a fine rose hue occur. The density of the Madagascar beryls ranges from 2·707 to 2·881 and in one case to 2·91, according to M. A. Lacroix.

Common beryls, but of muddy and even opaque hues, are sometimes found of enormous size. One from Grafton, New Hampshire, U.S.A., weighs 2900 lb. It is 4 ft. 3 in. long 32 in. in one direction and 22 in. in another, transverse to the last, across the crystal. A still larger crystal from the same locality was estimated to weigh nearly 2½ tons. But some of the Russian aquamarines and transparent or precious beryls are of considerable size and without flaw. An aquamarine weighing 225 troy ounces, and without a flaw, belonged to the emperor of Brazil. Good specimens may be seen in the Mineralogical Gallery of the British (Natural History) Museum. Emeralds are rarely free from flaws, even in the case of small stones. So large and finely-coloured an emerald as No. 1284 in the Townshend collection is an exceptional stone; it is nearly half an inch across. The emerald is usually step, that is, trap cut; the table should not be large. Perfect stones of the best colour, and without flaws, sell for £40 to £60, occasionally even £140, per carat.

The emerald and the aquamarine consist essentially of a silicate of alumina and of the rare earth glucina. In the emerald Wöhler has confirmed the presence of enough oxide of chromium to cause the green colour, for he coloured white glass with the same proportion, 0·19 per cent. Neglecting the oxide of iron, occurring in all varieties of beryl, and also the water and traces of other compounds, the composition in 100 parts of this mineral species will be:

Silica	66·8	Alumina	19·1
Glucina	14·1		

The emerald was employed in antique Roman jewellery, sometimes in the form of slices of the native prisms, some-

times in beads, and very rarely for intaglios. Antique engraved gems of beryl or aquamarine are not quite so rare.

The *smaragdus* of Theophrastus included with the beryl a number of quite different stones, such as the chrysocolla and dioptase. Pliny's *smaragdus* included, besides the above, the green chrysoberyl and the chrysoprase, as well as the green plasma, the prase, and green jasper. In native East Indian jewellery the emerald is usually cut *en cabochon;* this form conceals the flaws to a great degree. In Europe the step-cut is considered the most suitable style. Emeralds are occasionally engraved or carved. In the Hope collection there was a beautiful vinaigrette made out of two emeralds, $\frac{7}{8}$ inch in height, and $\frac{7}{8}$ inch across; it brought 145 guineas when sold by auction in 1886.

Beryl (including Emerald and Aquamarine) is represented in the Townshend Collection by eight specimens:

Emerald. Fine colour, polished flat, engraved with Persian characters, oval; $\frac{27}{32}$ in. by $\frac{21}{32}$ in.; coronet mount. (Hope catalogue, p. 45, No. 7.) Plate II. fig. 23. 1283—'69.

Emerald. Perfect colour, step cut, square, set lozenge-wise; $\frac{7}{16}$ in. diam.; bordered with 24 single-cut brilliants, and having on each shoulder of the ring 4 brilliants and 2 roses. 1284—'69.

Emerald. With six-rayed black star, subglobular, with face and back centrally flattened, circular; $\frac{1}{2}$ in. diam.; plain swing mount. (Hope catalogue, p. 46, No. 9.) Plate II. fig. 24. 1285—'69.

Aquamarine. Sea green, faceted, large table, round; $1\frac{5}{6}$ in. diam. and $1\frac{1}{6}$ in. thick; coronet mounted handle. (Hope catalogue, p. 49, No. 6.) Plate II. fig. 25. 1286—'69.

Aquamarine. Yellowish green, faceted, large table, oval; $1\frac{7}{12}$ in. by $1\frac{1}{8}$ in. and $\frac{11}{12}$ in. thick; coronet mounted handle. (Hope catalogue, p. 49. No. 4.) Plate II. fig. 26. 1287—'69.

Aquamarine. Perfect sea green, faceted, large table, oval; $1\frac{5}{8}$ in. by $1\frac{1}{2}$ in. and 1 in. thick; coronet mounted handle. (Hope catalogue, p. 48, No. 3.) Plate II. fig. 27. 1288—'69.

Aquamarine. Bluish sea green, faceted, long oblong; $1\frac{1}{6}$ in. by $\frac{7}{12}$ in. and $\frac{5}{12}$ in. thick; coronet mount. (Hope catalogue p. 50, No. 12.) Plate II. fig. 28. 1289—'69.

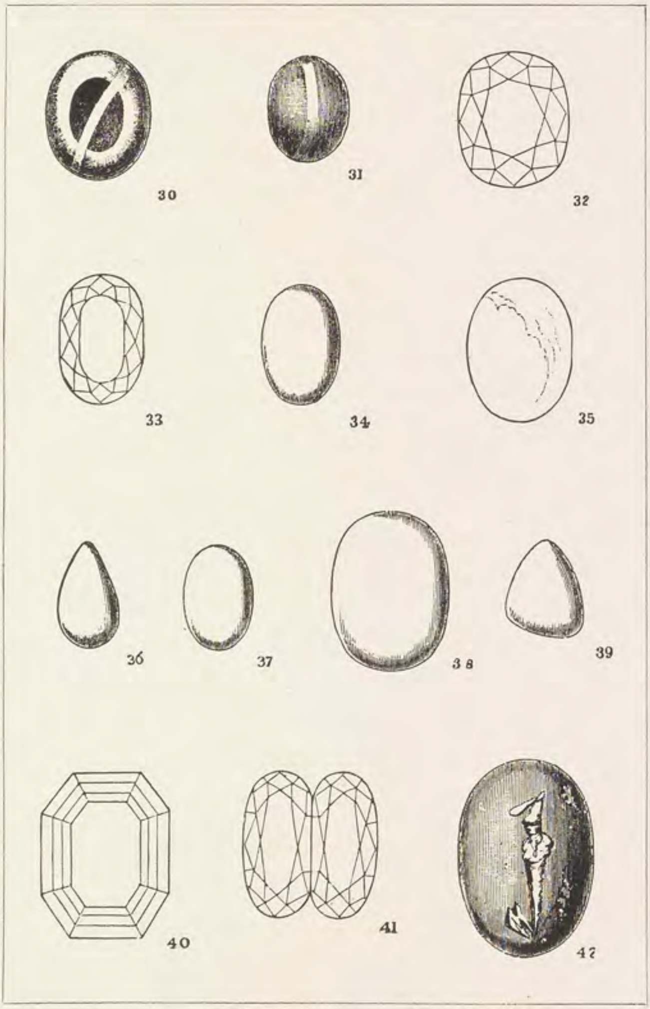
Aquamarine. Pale greenish grey, nearly colourless, step-cut, nearly square; $\frac{1}{2}$ in. by $\frac{11}{24}$ in.; coronet mount. (Hope, catalogue, p. 53, No. 4.) Plate II. fig. 29. 1293—'69.

Chrysoberyl.

The cymophane or true cat's-eye, the hard specimens called oriental chrysolite by jewellers, and the alexandrite are varieties of chrysoberyl. Their differences of hue and of physical appearance are not associated with any essential differences of composition. The colours of chrysoberyl range from columbine red through brownish yellow to leaf green; a golden yellow and a greenish yellow are not unusual. The coloured chrysoberyls are strongly dichroic;* some brownish specimens from this cause may present to the unassisted eye the aspect of tourmalines. The green leaf, or deep olive green variety, known as alexandrite, of which fine flawless specimens of large size have been sent from Ceylon, is remarkable for

* Frontispiece, Fig. 9.

PLATE III.—Chrysoberyl, Zircon, Opals, Quartz.



To face page 116.

appearing of a raspberry red hue by candle or lamplight. This mineral crystallizes in the orthorhombic system: twins are frequent. The hardness of chrysoberyl approaches that of the sapphire: it is 8·5. Its lustre and brilliancy are considerable. Its specific gravity averages 3·7; it is but slightly lowered by strong ignition.

Golden yellow ..	.. 3·84	Brownish yellow	.. 3·734
Greenish yellow	.. 3·76	Alexandrite ..	.. 3·644

The cymophane, or true cat's-eye, owes its chatoyancy, whether of pale steely whiteness as a flash, or as a line like a silver wire, to the orderly arrangement of an immense number of minute cavities along certain lines causing minute internal striations. The dark yellowish green hue is most prized; it is usually cut *en cabochon*. The chrysoberyl occurs in many localities, notably in Brazil and Ceylon, Connecticut, and the Urals. A fine specimen from the Hope collection is in the British (Natural History) Museum.

The chrysoberyl owes its colour chiefly to iron in the form of ferrous oxide; but traces of chromium and of manganese oxide also occur in it. Its percentage composition is roughly:

Alumina	.. 78	Glucina	.. 18
Ferrous oxide ..	.. 4		

Chrysoberyl (including Cymophane or true Cat's-eye) is represented in the Townshend Collection by eight specimens:

Chrysoberyl. Yellow, faceted, nearly circular; 1 in. by $\frac{15}{16}$ in.; coronet mount. 1297—'69.

Chrysoberyl. Pale yellowish green, brilliant-cut; $\frac{11}{16}$ in. by $\frac{9}{16}$ in.; coronet mount. 1304—'69.

Chrysoberyl. Cymophane, showing band of pearly light, circular, cut *en cabochon*; $\frac{3}{4}$ in. diam.; bordered with 16 diamonds set in silver on openwork mount. 1328—'69.

Chrysoberyl. Cymophane; $\frac{5}{8}$ in. by $\frac{9}{16}$ in.; coronet mount. 1329—'69.

Chrysoberyl. Cymophane; $\frac{11}{16}$ in. by $\frac{1}{2}$ in.; bordered with 28 small brilliants; plain claw mount. 1330—'69.

Chrysoberyl. Cymophane, greenish brown, oval, cut *en cabochon*; $\frac{11}{16}$ in. diam.; coronet mount. 1331—'69.

Chrysoberyl. Cymophane, oval, cut *en cabochon*, band of white light; $\frac{17}{24}$ in. by $\frac{7}{12}$ in.; coronet mount. (Hope catalogue, p. 57, No. 10.) Plate III. fig. 30. 1332—'69.

Chrysoberyl. Cymophane of dark green colour with band of bluish light, oval, cut *en cabochon*; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; coronet mount. (Hope catalogue, p. 58, No. 19.) Plate III. fig. 31. 1338—'69.

Phenakite.

Phenakite is but rarely used as a gem-stone. The colourless transparent variety may, however, be mistaken for a diamond, especially by candlelight, when the prismatic colours, or "fire," of a brilliant-cut specimen are conspicuous. The hardness of this stone lies between $7\frac{1}{2}$ and 8, while its specific gravity is close upon 3. Crystals of phenakite usually take the form of a low obtuse rhombohedron. This mineral is sometimes perfectly colourless and transparent, but more frequently is rather clouded and milky, or of a straw, sherry, or cinnamon tint. When viewed with a dichroiscope the ordinary image is colourless, the extraordinary image being of a warm yellow or brown, should the specimen examined possess any colour at all.

The best specimens of phenakite known come from the emerald and chrysoberyl mines at Takovaya, eighty-five

versts east of Ekaterinburg, Perm, Asiatic Russia: the matrix is a mica-schist; less important examples are found in Colorado, U.S.A.

In the Mineralogical Gallery of the British (Natural History) Museum there are fine specimens of phenakite both in crystals and in cut form: two of the latter weigh respectively, 43 and 34 carats.

Phenakite is one of the five species of precious stones which contain the earth glucina as an essential constituent —the others are beryllonite, euclase, beryl, and chrysoberyl. Its percentage composition is represented by the numbers:

Silica	54·2	Glucina	45·8

EUCLASE.

Euclase is rarely used as a gem-stone. It varies in hue from a pale straw colour through many qualities of green to indigo blue. Its hardness is 7·5, and its specific gravity about 3·1. It crystallizes in the monoclinic system, and exhibits trichroism. Fine crystals came from the neighbourhood of Villa Rica, Brazil, where it was associated with topaz in a chloritic schist. It occurs in the Urals. Its composition in 100 parts is approximately:

Silica	41·2	Glucina	17·4
Alumina	35·2	Water	6·2

Traces of iron, lime, tin and fluorine occur in euclase.

Beryllonite, another mineral species containing the earth beryllia (=glucina), has been cut occasionally as a gem-stone. It is a sodium glucinum phosphate, and crystallizes in the rhombic system. It occurs at Stoneham, Maine, U.S.A. Beryllonite is transparent and

colourless and presents no valuable optical characters entitling it to rank as a precious stone. It is, moreover, brittle and of no more than 6 degrees of hardness. But to the chemist its strange composition is interesting, while to the crystallographer its complex forms appeal.

ZIRCON.

The gem-stones known as jargoons as well as the true hyacinths or jacinths belong to the same mineral species. There are many circumstances which unite to make the zircon a beautiful and interesting gem. For it presents a considerable range of rich as well as of delicate hues; its surface lustre is brilliant, almost adamantine; while its chemical composition is rendered noteworthy through the predominant presence of the rare earth zirconia. Although zircon, even in its most richly coloured varieties, is but feebly dichroic, yet some specimens display a considerable amount of "fire," owing to their high dispersive power, while the majority depend for their brilliancy mainly upon their strong refraction of light, which approaches that of a diamond. Moreover the spectroscope reveals the presence, in many of the transparent specimens, of a series of black absorption bands (discovered by the author in 1866), which are characteristic, and have been attributed to small quantities of a uranium compound, to erbium and to an unknown element.* Zircon crystallizes in the tetragonal system, and usually occurs in short square prisms terminated by pyramids containing facets of tetragonal octohedra. Its hardness is about 7·5, but rather lower than this figure in the varieties

* Frontispiece, Fig. 11.

of lower density. The specific gravity of zircon demands special consideration, as this physical property presents, in the case of this mineral, features of quite singular interest. In fact the specific gravity of different specimens ranges from 3·98 to 4·86, a range more extensive than that of any other precious stone, indeed of any other mineral. Of the gem-varieties of zircon the least dense are those which are of a pure leaf-green colour, 3·98 to 4·18; then come the paler and duller green stones, 4·2 to 4·4; then the clouded orange or gold-coloured stones, 4·32 to 4·45; then the great bulk of yellow, orange, red, brown, puce, and white stones, 4·6 to 4·75; the flame-red zircons of Expailly, Auvergne, with a density approaching 4·86 conclude the series. The following set of determinations of the specific gravity of flawless cut specimens of zircon (both jargoons and hyacinths) will be useful for reference, particularly as the numbers represent the values obtained for stones of volume sufficient to secure accuracy; all the specimens save one were from Ceylon :—

Pure leaf-green	3·982	Golden, slightly opalescent	4·449
,, ,,	4·023	Greenish yellow	4·572
,, ,,	4·055	Yellow	4·623
,, ,,	4·076	,,	4·630
Pale grey-green	4·256	Puce	4·643
,, ,,	4·314	Deep red	4·681
,, ,,	4·346	,, ,, (Mudgee)	4·705
Golden, slightly opalescent	4·316	Pure white	4·687
,, ,, ,,	4·432	,, ,,	4·705

This tabular statement of specific gravities would be incomplete without reference to the change which many zircons undergo when strongly heated—most coloured zircons thus lose or change their original hue. Some become nearly or quite colourless, others from a brown or reddish hue change to a dull green. Now it is found

that zircons naturally of high density are not altered in this character by heating, but, on the other hand, that specimens of low density usually contract considerably after having been raised to a high temperature. Thus a green stone, having the low density of 4·0, acquired a density of 4·31 after it had been strongly heated; while a gold-coloured specimen was raised from 4·375 to 4·657. Yet so long ago as 1875 I described a low density dull green zircon which suffered no condensation by being heated, but retained its original density of 4·02. The recent researches of Dr. S. Stevanović and of Mr. L. J. Spencer point to the existence of three modifications of zircon-material. One of these has a permanent density of 4; another has the same density, which, however, can be raised by heating; a third modification has the permanent density of 4·7. All the different densities and changes of density which have been observed can be explained on this hypothesis.

Several curious phenomena are presented by certain varieties of zircon. For example, all the bright green stones of low density as well as some others of ill-defined greyish yellow and greenish yellow hues give rise to a brilliant orange light when applied to a copper-wheel charged with diamond dust in the operation of grinding. Then again the gold-coloured zircons having a density of about 4·4 continuously glow with a fine orange incandescence in the flame of a Bunsen-burner; this effect is apparently produced by the presence of thoria.

Ceylon yields the finest and largest specimens of precious zircon. New South Wales contains several deposits in which beautiful zircons occur: the stones

from Mudgee have been known for some years. The zircons from Expailly in Auvergne are quite typical hyacinths; they possess a beautiful aurora-red hue, but are, as a rule, very small. The market-value of the gem-varieties of zircon is small. Fine red columbine red and cinnamon-hued stones may be bought at 5s. per carat: yellow stones and dull green specimens are still cheaper, but the deep and rich leaf green stones and even those which are of a pale though pure green colour, as also those which are brilliantly white, bring larger sums. The largest "camellia-leaf" green zircon, weighing over 19 carats, with which I am acquainted brought 26s. the carat. But it was London-cut and no doubt weighed 5 or 6 carats more when imported in its native cut state. Such a stone, of the same high quality and colour and weighing 18½ carats, cost £18 10s. in Ceylon; but it had to be re-cut and lost 2 carats in the operation.

White or colourless zircons are used in lieu of diamonds by wealthy natives in Ceylon. They have been employed in European jewellery also; sometimes a fine white zircon set in a massive ring of gold has been pawned as a brilliant and not redeemed. A file will not scratch a facet of a zircon, so that this test for "paste" is inapplicable. But though much harder than glass, and harder even than rock crystal, zircon is unfortunately somewhat brittle, and easily becomes chipped in wear. An examination of a large number of engraved gems labelled hyacinth or jacinth has proved them not to be of true hyacinth, that is red zircon, but of garnet, either hessonite or cinnamon stone, or of almandine.

Putting on one side minor and accidental ingredients, although to these the colours, absorption-bands,

opalescence, etc., of the stone are due, the percentage composition of zircon approaches :—

Zirconia	67	Silica	33

Zircon is represented in the Townshend Collection by six specimens:

Zircon, or Jargoon. Rich brown, $\frac{5}{8}$ in. by $\frac{1}{2}$ in.; plain mount.

Zircon, or Jargoon. Sherry yellow, slightly opalescent, brilliant-cut; diam. $\frac{11}{24}$ in.; coronet mount. 1281-82—'69.

Zircon, or Jargoon. Pale opalescent green; $\frac{3}{8}$ in. by $\frac{1}{3}$ in.; brilliant-cut; plain mount. 1305—'69.

Zircon, or Jargoon. Leaf green, faceted; $\frac{7}{12}$ in. by $\frac{1}{2}$ in.; plain mount. 1322—'69.

Zircon, or Jargoon. Brownish green, brilliant-cut, oval; $\frac{3}{4}$ in. by $\frac{5}{8}$ in.; coronet mount. (Hope catalogue, p. 56, No. 3.) Plate III. fig. 32. 1194-'69.

Zircon, or Jargoon. Brownish green, long oval; $\frac{5}{8}$ in. by $\frac{7}{16}$ in.; plain claw mount. (Hope catalogue, p. 57, No. 6.) Plate III. fig. 33. 1298—'69.

See also Appendix facing page 158.

SPODUMENE.

Until lately spodumene was not recognised as a stone which could be cut and polished as a gem; but a large importation from Brazil of brilliant and transparent crystals of yellow spodumene led to some specimens being cut and polished. The easy cleavage of the stone renders its working and mounting difficult matters. Spodumene crystallizes in the monoclinic system, and resembles in appearance the chrysoberyl. Its hardness is 7, and its specific gravity 3·2. It contains in 100 parts :—

Silica	64·2	Iron oxide	·4
Alumina	29·0	Lithia	6·0

with traces of soda, lime, potash, and water.

Spodumene is now represented in the Museum Collection.

See Appendix facing page 158.

HIDDENITE.

This beautiful green stone is transparent and of a brilliant green hue, not unlike that of a rather yellowish green emerald. It is a variety of spodumene, a mineral generally of a dull well-nigh opaque greyish or creamy colour, but sometimes of a brilliant straw yellow and transparent. Hiddenite rarely occurs in crystals sufficiently large for cutting into gem-stones. A cut stone, however, nearly perfect, weighed $2\frac{1}{2}$ carats, and was sold for more than $125 a carat. It has been found as yet in but one locality, Alexander County, North Carolina. It was discovered by Mr. W. E. Hidden. Its hardness is $6\frac{3}{4}$, and its specific gravity 3·17.

KUNZITE.

This newly-discovered variety of spodumene is remarkable for the very large size of the crystals in which it occurs, for the peculiar rosy lilac hue which it presents and for its perfect transparency. Many brilliant and perfect cut stones have been fashioned from this variety of spodumene, which is found near Pala, in San Diego County, California, at a locality famous for its lithia minerals, such as lepidolite, amblygonite, and tourmaline. Kunzite, so named after Dr. G. F. Kunz, the gem expert, resembles the yellow spodumene of Brazil, and the green spodumene (hiddenite) of North Carolina, in its transparency, its easy cleavage, its hardness of $6\frac{3}{4}$, and its specific gravity of 3·18, but, unlike these varieties, it exhibits a characteristic phosphorescence after exposure to the influence of radium bromide and the X-rays. As the colour of this mineral is pale, it is seen to perfection only in somewhat large specimens—for example, in a

brilliant-cut stone of 20 carats or more. This is the case with the precious stone which kunzite most nearly resembles in hue, namely, pink topaz.

Opal.

Among the numerous forms or varieties of the mineral species called opal, one kind alone is prized as a gem-stone. This is the noble or precious opal, which is distinguished by its play of brilliant rainbow colours. These are not caused by any coloured substances as constituents, but are due to a peculiar structure of this mineral. Although by transmitted light the precious opal appears milky or cloudy and yellow, by reflected light it exhibits orange, red, blue, green, and many other beautiful hues. These colours are produced by a mechanical or physical structure, which consists of a multitude of fissures, the sides of which are minutely striated, and which causes the diffraction and decomposition of the white light which falls upon them. The size of these striations and fissures influences the colour and its distribution within the stone, some specimens showing a predominance of one set of hues, say red and orange, and others exhibiting chiefly green, sea green, and blue tints. Sometimes, too, the patches of colour are of moderate and uniform size; sometimes they are large and irregular. The precious opal is, moreover, sometimes so milky as to be almost opaque; sometimes, as in many Queensland and Honduras specimens, it is nearly as transparent as glass. An intermediate condition, provided the fiery play of colours be well developed, is most highly prized; the best opals from Hungary and many of those from Mexico and from New South Wales are of this kind. The singular "black opal,"

which offers fine flashes of bright colours on a dark grey background, is found in perfection among the opal veins of Lightning Ridge, New South Wales.

The opal consists essentially of silica, but it differs from quartz—that is, rock crystal—in two important particulars: it is vitreous, not crystalline, and it contains combined water. The precious or noble opal usually contains from 9 to 12 parts of water in 100; but it may be dried so as to lose for a time a small part of this moisture without injury to its beauty; in fact, the whole of the water present is not essential to the mineral. The specific gravity of opal is lower than that of quartz or rock crystal—about 2·2. Its hardness is about 6, or even as low as 5·5. Its fragility and softness, and its liability to injury from oily or greasy matter, render the opal unfit for a ring-stone, but it may be used to advantage in pendants, bracelets, and ornaments for the head. A foolish but prevalent notion that the opal carries bad luck with it is of quite modern origin, but lowers the commercial value of the stone. Moreover, the great diversity in the quality of this gem renders it impossible to assign definite prices to opals of definite weights, though it may be said that a fine opal of 1 carat is worth about £2.

Besides the more usual form of precious opal, we have the Mexican fire opal, showing, along with a slight cloudiness, a rich orange-red hue like that of a glowing fire; and the harlequin opal, in which the brilliant patches of colour are small, angular, variously tinted, and uniformly distributed. The common or non-prismatic opal is found of many hues, rose-coloured, green, milky, agatoid, and with dendritic markings. Hydrophane is a variety which becomes transparent when saturated with water or, as

Sir James Dewar has shown, with liquid air, and sometimes even shows colours: hyalite is transparent; cacholong is milky and nearly opaque.

Opals are cut with a convex surface; their brilliancy is often increased by moderate warmth.

Root of opal contains veins and specks of opal in a dark-coloured ferruginous matrix, which may be still further darkened by soaking in oil of vitriol. Cameos are sometimes cut so as to show a head or figure in precious opal thrown up against a background of the dark-brown ferruginous matrix of the stone.

Opal is represented in the Townshend Collection by seventeen specimens:

Opal. Precious, with patches of brilliant colour (the *harlequin* opal) heart-shaped; $\frac{3}{4}$ in. by $\frac{9}{16}$ in.; bordered with 34 roses, and having 2 roses and 4 brilliants on each shoulder of the shank; openwork mount. 1220—'69.

Opal. Precious, with brilliant red, yellow, and green flashes; oval; $\frac{3}{4}$ in. by $\frac{1}{2}$ in.; bordered with 34 diamonds set in silver, and having 3 diamonds on each shoulder of the shank; openwork mount. 1221—'69.

Opal. Precious, long pear-shaped; $\frac{7}{12}$ in. by $\frac{1}{3}$ in.; open blue-enamelled coronet mount, with 6 claws, a brilliant on each claw, and 6 brilliants in the hollows between the claws. 1222—'69.

Opal. Precious, with large colour flashes, oval; $\frac{9}{16}$ in. by $\frac{7}{16}$ in.; bordered with 24 brilliants; plain mount. 1223—'69.

Opal. Precious, oval; $\frac{1}{3}$ in. by $\frac{5}{24}$ in.; bordered with 16 roses; openwork mount. 1224—'69.

Opal. Precious, with broad flashes of colour, long oval; $\frac{2}{3}$ in. by $\frac{3}{8}$ in.; claw mount, with blue enamel between the claws. 1225—'69.

Opal. Precious, Mexican, a *fire opal* of deep amber colour, with red and green flashes, long oval; $\frac{3}{8}$ in. by $\frac{5}{12}$ in.; blue enamelled border, on gold mount. (Hope catalogue, p. 79, No. 26.) Plate III. fig. 34. 1226—'69.

Opal. Precious, Hungarian, very brilliant *harlequin* colours; circular $\frac{5}{12}$ in. diam.; coronet mount, on chased shank. (Hope catalogue, p. 78, No. 19.) 1227—'69.

Opal. Precious, Hungarian, oval; $\frac{11}{16}$ in. by $\frac{9}{16}$ in.; plain mount with claws. (Hope catalogue, p. 79, No. 28.) 1228—'69.

Opal. Precious, a *fire opal* of deep amber colour, with orange and green flashes, oval; $\frac{5}{6}$ in. by $\frac{1}{2}$ in.; plain mount. 1229—'69.

Opal. Precious, Hungarian, pinkish grey, oval; $\frac{3}{4}$ in. by $\frac{7}{12}$ in.; coronet mount. (Hope catalogue, p. 81, No. 42.) Plate III. fig. 35. 1230—'69.

Opal.—Precious, Hungarian, liver colour, with purple flashes, ovate; $\frac{1}{2}$ in. by $\frac{1}{3}$ in.; plain mount. (Hope catalogue, p. 81 No. 39.) Plate III. fig. 36. 1231—'69.

Opal.—Hungarian, one-third white, with coloured flashes, two-thirds brown, oval; $\frac{1}{2}$ in. by $\frac{3}{8}$ in.; coronet mount. (Hope catalogue, p. 80, No. 34.) Plate III. fig. 37. 1232—'69.

Opal. Mexican, deep brown, with play of green light, oval; $\frac{13}{16}$ in. by $\frac{5}{8}$ in.; coronet mount. (Hope catalogue, p. 78, No. 22.) Plate III. fig. 38. 1233—'69.

Opal. Hungarian, grey, with black dendrites and greenish blue flashes, triangular; $\frac{1}{2}$ in. across; coronet mount. (Hope catalogue, p. 80, No. 33.) Plate III. fig. 39. 1234—'69.

Opal. Honey yellow, with dendrites, nearly hemispherical; $\frac{3}{4}$ in. by $\frac{5}{8}$ in.; coronet mount. 1235—'69.

Opal. Honey yellow, faceted, circular; $\frac{7}{24}$ in. diam.; coronet mount. 1236—'69.

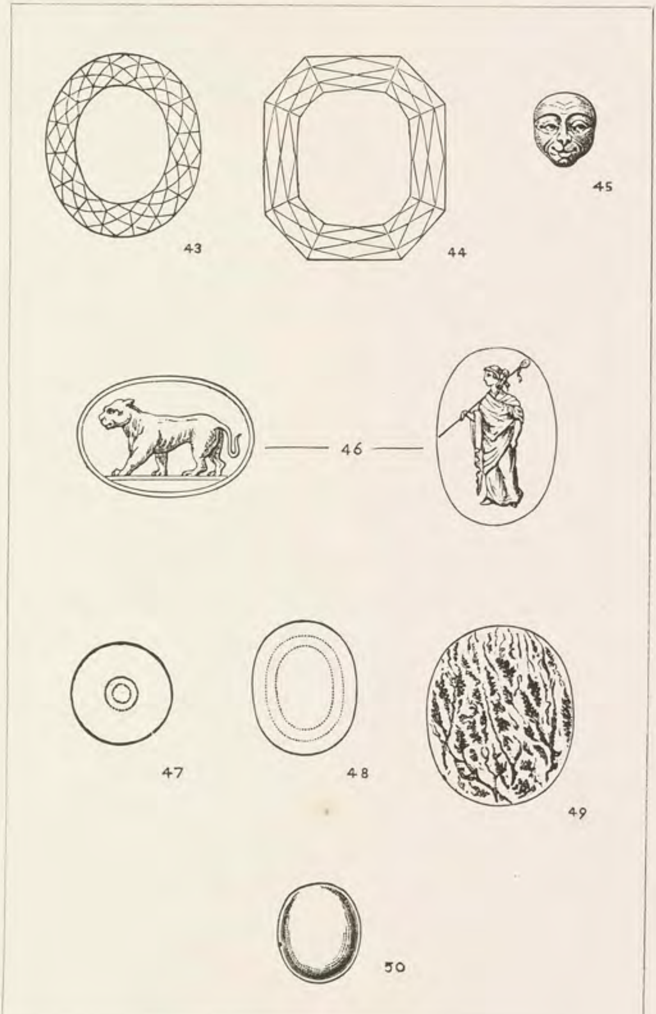
See also Appendix facing page 158.

Quartz.

The purest form of quartz is represented by the colourless rock crystal so largely used for ornamental objects in the cinque-cento time, and now employed extensively for optical purposes. It is silica, the oxide of silicon (SiO_2), and contains 47·0 per cent. silicon and 53·0 per cent. oxygen. The coloured varieties contain sometimes very small traces of foreign matters to which it is presumed their colours are due: but there are doubts in many cases as to the exact nature of the causes of these colorations when they are not of merely mechanical or physical origin. The presence of nickel compounds in the green chrysoprase, and of titanium in the rose quartz of Rabenstein is believed to be the cause, in these instances respectively, of the colours of these two varieties of quartz; moreover, there is no doubt that many of the red, green, and brown colours shown by members of this group are due to manganese and iron oxides, and to silicates of these metals. Traces of water, alumina, lime, and magnesia also occur, but these ingredients are of little importance as regards the source of the hue of different varieties of quartz.

Quartz crystallizes in the rhombohedral system, its commonest form being a six-sided prism, striated transversely, and terminated by a six-sided pyramid. In amethyst there are many fine undulatory layers, so superimposed that a slice across a crystal shows their triangular section distinctly and reveals as it is turned round the difference of colour caused by their structure and arrangement. The alternate layers are endowed with right and left handed powers of rotatory polarization. The "rippled" fracture, and the feathery flaws of amethysts are due to these fine layers.

PLATE IV.—Quartz, Moonstone.



To face page 130.

Quartz is doubly refractive: the coloured specimens are dichroic. The indices of refraction for the yellow ray are $\omega = 1{\cdot}5442$ and $\epsilon = 1{\cdot}5533$. The colours of oppositely polarized rays are, in the case of the amethyst, reddish purple and bluish purple.

The hardness of pure rock crystal is 7, and its specific gravity 2·65. A list of specific gravities of some of the purest forms of quartz will be useful, but it must be remembered that the dark-coloured and opaque varieties are much denser, sometimes reaching 2·8.

Milky quartz	2·642	Brown cairngorm ..	2·656
Pure rock crystal ..	2·650	Amethyst	2·659
Very dark ditto	2·662		

Quartz may be melted by the aid of the oxyhydrogen blowpipe to a limpid glass having the specific gravity 2·2 and the hardness 5.

The very numerous varieties of quartz cannot be classified accurately, for many of them owe their peculiarities to intruding minerals of many sorts. The quartz cat's-eye includes fine fibres of asbestos or crocidolite; avanturine quartz, minute spangles of mica; and so on. But the pellucid varieties group themselves near rock crystal, while the translucent kinds may be arranged under chalcedony. The former group includes amethyst and cairngorm, the latter sard, chrysoprase, and plasma. We cannot here find space for more than an alphabetical list of the chief members of the great quartz family.

Agate—layers of chalcedony, jasper, rock crystal; also mottled.
Agate-jasper—a variety of agate containing jasper.
Amethyst—transparent, purple, honey yellow or greenish yellow.
Avanturine—transparent, with golden brown or green iridescent spangles.
Beekite—silicified corals, shells, or limestone resembling chalcedony.

Bloodstone—translucent to opaque; green with red spots.

Cairngorm—transparent and smoke grey, yellow or brown.

Cat's-eye—translucent grey or greenish, with chatoyancy.

Chalcedony—cloudy or translucent; white, yellow, brown, blue.

Chrysoprase—translucent; pale bluish green.

Cornelian—translucent, like horn; yellow, brown, red.

Egyptian jasper—opaque, concentric, and other layers of yellow, brown, or black.

Heliotrope—a chalcedonic base, with much green delessite (chlorite) and red spots of iron oxide.

Jasper—opaque; dull red, dull green, and ochre yellow.

Milky quartz—opalescent or milky, yellowish by transmitted light.

Onyx—bands or strata of white, grey, black; translucent to opaque.

Plasma—very translucent; rich leaf green.

Porcelain jasper—sub-translucent; often white and pink.

Prase—translucent, but spotted; muddy olive green.

Riband jasper—opaque bands, dull red and dull green; sometimes yellow.

Rock crystal—transparent and colourless.

Rose quartz—translucent and pale pink.

Sapphirine quartz—translucent and pale greyish blue.

Sard—very translucent; red, brownish red, crimson, blood red, blackish red, golden, amber.

Sardonyx—a stratified stone, having one or more strata of sard.

Smoky quartz—transparent; of various hues of grey and brown.

But this list by no means exhausts the varieties of quartz, for of agate alone we have fortification agate, moss agate, and mocha stone, eye agate, and brecciated agate. All of these stones, and indeed the majority of those in the list just given, so far as their colours and markings are natural and not due to artificial treatment, consist of amorphous or crystalline silica, variously arranged or disposed, and associated with colouring oxides and silicates containing oxides of iron, manganese, or nickel. The claim of very few of these varieties of quartz to the rank of precious stones can be sustained. It is not merely that they are abundant, but their brilliancy and beauty are not sufficiently pronounced to entitle them to high rank amongst stones for jewels. The great merit of the artistic

work executed in these materials, in Greek, Roman, and cinque-cento times has indeed ennobled the sard, the onyx, the prase, the sapphirine quartz, the jasper, etc.; but except in the forms of cameos and intaglios these stones are but little esteemed. Rich deep-coloured amethysts, with the colour not quite uniformly distributed throughout their substance, are perhaps the most prized form of quartz. The colour of such amethysts gains in beauty from the dichroism of the stone and from its peculiar rippled and parquetry structure. Such amethysts are wrongly called *oriental* amethysts by jewellers (some do come from India), for the true oriental amethyst is a purple sapphire, not quartz at all, and an excessively rare stone.

The localities for choice specimens of amethyst, sard, chrysoprase, chalcedony, etc., are legion. The amethysts of Brazil and Ceylon, the agates of Uruguay, the chrysoprases of Silesia, the cornelians of Arabia, and the jaspers of Egypt are famous.

Not only have the dark-coloured onyxes of commerce been artificially dyed or stained, but a large proportion of agates, cornelians, sards, etc., have been similarly altered. A moderate heat reddens many varieties of quartz originally grey and brown, while a soaking in sugar or honey, followed by treatment with strong sulphuric acid, brings out black and white bands in the natural grey onyx.

Hydrochloric acid develops a lemon-yellow colour in white chalcedony, while a strong blue colour may be imparted by causing Prussian blue to be precipitated within the stone by alternate soaking in solutions of green vitriol and of prussiate of potash.

Quartz (including Cairngorm, Amethyst, Plasma, Chrysoprase, Chalcedony, Agate, and Oynx) is represented in the Townshend Collection by thirty-five specimens:

Rock Crystal. Colourless, circular, brilliant-cut; $\frac{1}{2}$ in. diam.; coronet mount. 1180—'69.

Cairngorm, or Smoky Quartz. Octagonal faceted; $\frac{5}{8}$ in. by $\frac{3}{4}$ in.; coronet mount. 1181—'69.

Cairngorm. Straw yellow, faceted, $\frac{5}{8}$ in. by $\frac{3}{4}$ in. and $\frac{5}{8}$ in. thick; coronet mount. (Hope catalogue, p. 86, No. 9.) Plate III. fig. 40. 1182—'69.

Cairngorm. Yellow, oval; 1 in. by $\frac{3}{4}$ in.; claw mount. 1183—'69.

Cairngorm. Yellow, with feather consisting of many minute cavities, faceted, oblong; $1\frac{1}{8}$ in. by $1\frac{1}{12}$ in. and $\frac{1}{2}$ in. thick; coronet mounted handle. 1185—'69.

Amethyst and Cairngorm. Purple and smoky, twin stone, each half long oval, faceted, and $\frac{17}{24}$ in. by $\frac{1}{3}$ in.; plain mount. (Hope catalogue, p. 86, No. 10.) Plate III. fig. 41. 1186—'69.

Amethyst. Oval, biconvex lens, containing four large cavities, with movable liquid and bubbles; 1 in. by $\frac{3}{4}$ in.; plain swing mount. (Hope catalogue, p. 85, No. 1.) Plate III. fig 42. 1187—'69.

Amethyst. Heart-shaped, rose-cut; $\frac{11}{12}$ in. by $\frac{11}{12}$ in.; coronet mount. (Hope catalogue, p. 89, No. 29.) 1189—'69.

Amethyst. Deep coloured, faceted, oval; 1 in. by $\frac{5}{8}$ in. and $\frac{1}{2}$ in. thick; coronet mount. (Hope catalogue, p. 88, No. 28.) Plate IV. fig 43. 1190—'69.

Amethyst. Rich colour, striped, faceted, $1\frac{1}{12}$ in. by $\frac{23}{24}$ in. and $\frac{1}{2}$ in. thick; coronet mount. (Hope catalogue, p. 87, No. 19.) Plate IV. fig. 44. 1191—'69.

Quartz. Yellow and pale pink, carved as a monkey's face; $\frac{1}{3}$ in. by $\frac{7}{24}$ in.; plain mount. (Hope catalogue, p. 95, No. 5.) Plate IV. fig. 45. 1193—'69.

Plasma. Engraved, with a Cupid holding a butterfly over a torch, oval; $\frac{5}{12}$ in. by $\frac{1}{3}$ in.; plain mount. 1196—'69.

Plasma. Engraved, with a Cupid resting on a staff, oval; $\frac{1}{3}$ in. by $\frac{1}{4}$ in.; plain mount. 1197—'69.

Plasma. Engraved, with two female figures, long oval; $\frac{11}{24}$ in. by $\frac{1}{3}$ in.; coronet mount. 1198—'69.

Chrysoprase. Face table cut, back *en cabochon*, oval; $\frac{11}{12}$ in. by $\frac{2}{3}$ in.; solid plain mount. 1199—'69.

Chrysoprase. Engraved in high relief, with laurel-wreathed head, oval; $1\frac{1}{12}$ in. by $\frac{3}{4}$ in.; plain mount. 1200—'69.

Chalcedony. Greenish yellow, nearly circular; $\frac{1}{3}$ in. diam.; plain mount. 1201—'69.

Chalcedony. Yellowish green, *en cabochon*, oval; $\frac{1}{4}$ in. by $\frac{5}{24}$ in.; solid chased mount. 1202—'69.

Chalcedony. Clouded, dull apple green, *en cabochon*, oval; $\frac{5}{8}$ in. by $\frac{7}{12}$ in.; coronet mount. 1203—'69.

Chalcedony. Grey blue, translucent, engraved with the Olympian Zeus, convex oval; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; plain mount, 1204—'69.

Avanturine Quartz. Spangled green, oval; $\frac{3}{4}$ in. by $\frac{5}{12}$ in.; plain mount. 1205—'69.

Agate. White chalcedony, with reddish brown patch, oval; $\frac{5}{6}$ in. by $\frac{3}{4}$ in.; coronet mount. 1206—'69.

Agate. White chalcedony, with light brown lines, some concentric, oval; $\frac{11}{12}$ in. by $\frac{3}{4}$ in.; two perforations; coronet mount. 1207—'69.

Chalcedony on Amethyst. The upper chalcedonic layer of brownish white cut to represent a panther, and a narrow border; the convex back of amethyst engraved with a Bacchante; oval; $\frac{5}{8}$ in. by $\frac{7}{12}$ in.; in an octagonal setting on double-swivel ring. (Hope catalogue, p. 86, No. 5.) Plate IV. fig. 46. 1208—'69.

Onyx. White and brown striped; $\frac{3}{4}$ in. by $\frac{5}{12}$ in.; plain mount. 1209—'69.

Onyx; eyed Agate. Hemispherical; $\frac{1}{2}$ in. diam.; coronet mount. (Hope catalogue, p. 92, No. 8.) Plate IV. fig. 47. 1210—'69.

Onyx. Three layers, brown, white, and black, oval; $\frac{2}{3}$ in. by $\frac{7}{12}$ in.; plain solid mount. (Hope catalogue, p. 92, No. 1.) Plate IV. fig. 48. 1211—'69.

Cornelian. Red, engraved with Persian characters and foliage, tabular; $\frac{3}{4}$ in. by $\frac{2}{3}$ in.; plain mount. 1212—'69.

Moss Agate. Pale purple, chalcedonic base, with jasper; oval, convex; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; coronet mount. 1213—'69.

Mocha Stone. Grey, with dark brown dendrites; oval; 1 in. by $\frac{19}{24}$ in.; coronet mount. 1214—'69.

Mocha Stone. Grey, with black dendrites, oval; 1 in. by $\frac{3}{4}$ in.; coronet mount. (Hope catalogue, p. 81, No. 40.) Plate IV. fig. 49. 1215—'69.

Bloodstone, or Heliotrope. Tabular, oval; $\frac{11}{24}$ in. by $\frac{3}{8}$ in.; plain mount. 1216—'69.

Cat's-eye. Honey yellow, *en cabochon*, high and narrow; $\frac{3}{4}$ in. by $\frac{3}{8}$ in. and $\frac{5}{12}$ in. thick; coronet mount. 1217—'69.

Cat's-eye. Pale yellow grey, *en cabochon*, oval; $\frac{5}{12}$ in. by $\frac{1}{3}$ in.; plain mount. 1218—'69.

Cat's-eye. Brown, *en cabochon*, dished back, oval; $\frac{23}{24}$ in. by $\frac{2}{3}$ in.; bordered with 20 brilliants, and with several roses on the pierced shoulders; set in silver on gold shank. 1219—'69.

Lapis-lazuli.

Lapis-lazuli or azure stone is not a definite mineral but a mixture, in variable proportions, of several minerals. Generally calcite forms the chief part of the colourless patches in the stone, but there will be present two or even three complex silicates possessing a beautiful blue colour. One of these is known as haüyne or haüynite, another is true ultramarine, and another is called sodalite. They are all silicates, and all contain much alumina, but soda is also present, as well as lime and iron. But it is the presence of sulphur in two forms of combination, namely as sulphide and as sulphate, which distinguishes the blue pigment, obtained by the treatment of lapis-lazuli, from all other blue compounds. This pigment has been very successfully imitated, not only as to colour but as to chemical constituents, by chemical art. It should be added here that the minute brass yellow specks, or spangles, which are commonly seen in lapis, are iron pyrites. Lapis was the sapphire of the ancients.

Lapis-lazuli occurs in Transylvania, Siberia, Tartary, Persia, China, Tibet, and Brazil. The richly coloured varieties are used for beads and for mosaic work and inlays in bijouterie, vases, furniture, and even in the internal decoration of buildings.

The hardness of lapis-lazuli lies between 5 and 5·5; its specific gravity is about 2·4. By moderate heating the blue colour of this mineral is generally unaffected, though in some cases it may actually be deepened. Carbonic acid does not affect it, nor does a cold weak solution of alum. Strong acids decompose it, the colour disappearing and sulphuretted hydrogen being given off.

The blue mineral called lazulite, although it sometimes presents an appearance slightly resembling that of lapis-lazuli, is not connected with the latter species by chemical constitution, for it is a phosphate, not a silicate (*see* page 88, under turquoise).

A thin section of lapis-lazuli constitutes a most beautiful microscopic slide. The perfect transparency and superb colour of the blue portions are characteristic. Until thus seen by transmitted light it would not be imagined that a mineral which appears by reflected light to be almost opaque could allow the passage of so much light through it.

There is one specimen of Lapis-lazuli in the Townshend Collection:

Lapis-Lazuli. Deep blue, with a few minute spangles of pyrites; tabular, oval; $\frac{5}{12}$ in. by $\frac{3}{8}$ in.; solid mount.
1324—'69.

Iolite

called also dichroite and *saphir d'eau*, and known to mineralogists as cordierite, is a beautiful and curious stone, remarkable for its pleochroism. Its crystals belong to the rhombic system. Good specimens, such as are occasionally met with in Ceylon, show in different directions of the crystal a soft lavender-blue, a greyish white, and a straw colour.* Iolite is frequently full of flaws and almost opaque; its beautiful change of colour is then very imperfectly seen. The hardness of iolite is above 7; its specific gravity is 2·6 to 2·66. One hundred parts of iolite on an average contain about:—

Silica	49	Magnesia	10
Alumina	33	Lime	1
Ferrous oxide	5	Water	1

* Frontispiece, Fig. 5.

Iolite (known also as Cordierite) is represented in the Townshend Collection by two specimens:

Iolite, or Dichroite. Pale violet, showing oblique cleavage lines, *en cabochon*, oval; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; claw mount. 1267—'69.

Iolite, or Dichroite. Pale blue, showing oblique cleavage lines, *en cabochon*, oblong, rounded ends; $\frac{1}{2}$ in. by $\frac{1}{4}$ in.; claw mount 1268—'69.

Crocidolite

is, or rather gives rise to, one of the minerals which has been termed cat's-eye. It occurs of three distinct colours —brownish yellow or gold (tiger eye), indigo or greenish blue, and dull red. When cut *en cabochon* of an oval form, with a high ridge, and with the longer diameter of the oval at right angles to the direction of the fibres or filaments which the mineral includes, crocidolite shows a good line of light and presents a brilliant appearance. It always contains a chalcedonic base; indeed the best specimens, which now come from Griqualand West, South Africa, and have a hardness of nearly 7, and specific gravity of 2·8, are essentially pseudomorphs after crocidolite, and not the unchanged mineral itself, which is softer and heavier. This stone is related to hornblende and asbestos, and has approximately this composition in 100 parts:—

Silica	51	Soda	7
Oxides of iron	34	Magnesia	2
Water	3		

Bronzite and hypersthene are two other minerals resembling crocidolite in their metallic reflections, and consisting of silica, iron oxides, and magnesia.

There is one specimen of Quartz after Crocidolite in the Townshend Collection:

Crocidolite. Dark bluish-green, with band of light, cut *en cabochon*; $\frac{3}{4}$ in. by $\frac{7}{12}$ in.; coronet mount. 1336—'69.

Labradorite.

Labrador spar is a felspar, crystallizing in the triclinic system. It is usually translucent rather than transparent, and by transmitted light appears of a grey colour. Owing chiefly to a peculiarity in its intimate or minute structure, which resembles a complex system of gratings, labradorite often shows magnificent chatoyant reflections of brilliant blues, sea green, orange, puce, amber, and peach-blossom hues, in fact, a coloured metallic sheen. It should be cut with a nearly plane or but slightly convex surface. It occurs, associated with hypersthene and amphibole, of fine quality, in the island of St. Paul, and in large masses on the coast of Labrador; also in Finland, Volhynia, the United States, and Queensland. Labradorite has the hardness 6, and the specific gravity 2·7 to 2·75. In 100 parts it contains:—

Silica	55·5	Iron oxides	2·0
Alumina	26·5	Lime	11·0
Soda	4·0		

In some specimens there is less lime, but, instead, a small percentage of potash and magnesia.

Moonstone or Adularia.

This is a variety of felspar, and generally of that species of monoclinic felspar called orthoclase or orthose. Moonstone is found at St. Gothard, and very abundantly in

Ceylon. It differs from ordinary orthoclase in the remarkable pearly reflection of light which it exhibits in certain directions. The most esteemed specimens are those in which the chatoyancy has a distinctly bluish hue. Some varieties are nearly opaque; a chocolate-coloured sort has also been found. The bluish stones only possess a market-value. The hardness of moonstone is 6, and its specific gravity almost invariably 2·58. It contains in 100 parts:—

Silica	64·5	Alumina	18·5
Potash	15·0	Soda	1·0

with traces of lime and magnesia.

SUNSTONE OR AVANTURINE FELSPAR

is usually a variety of oligoclase, or soda lime felspar, having golden yellow, reddish, or prismatic internal reflections, due to the presence of minute imbedded and scattered crystals of hæmatite, göthite, or mica. Some avanturine is, however, a mixture of albite and orthoclase, and the same name is given to quartz containing brilliant imbedded micacious crystals. The green avanturine, called amazon-stone, is microcline, a felspar.

Felspar is represented in the Townshend Collection by three specimens:

Labradorite. Grey, with blue, green, and orange chatoyancy, slightly convex, circular; $\frac{7}{12}$ in. diam.; claw mount. 1292—'69.

Sunstone. Avanturine felspar of delicate reddish-brown colour, *en cabochon*, oval; $\frac{5}{12}$ in. by $\frac{1}{3}$ in.; solid mount. 1293—'69.

Moonstone. Adularia, orthoclase felspar, having a bluish-white chatoyancy, *en cabochon*, oval; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; plain mount. (Hope catalogue, p. 97, No. 6.) Plate IV. fig. 50. 1294—'69.

See also Appendix facing page 158.

Obsidian or Volcanic Glass

is often nothing more than fused or vitreous orthoclase—that is, potash felspar. But obsidian frequently contains many other minerals in small quantities, such as augite and olivine; in fact, obsidian is a melted lava, and contains the various minerals of the lava melted or else associated together. Obsidian when transparent has about the specific gravity 2·4, and is softer than crystalline felspar. Black specimens of it resemble black garnet, spinel, and tourmaline, but are much more translucent in thin splinters, as well as striated and full of bubbles.

Epidote.

The various hues of olive, brownish, and pistachio green which are presented by tourmaline occur also in great measure in epidote. The latter mineral is, however, less dichroic than the former, although in some green Siberian and Brazilian specimens an emerald green image and a yellow one may be seen in the dichroiscope. The most famous locality is the Knappenwand, Salzburg. The hardness of epidote is about 6·5, and its specific gravity 3·3 to 3·4. It occurs in oblique prisms, often much elongated. Green epidote presents in 100 parts about the following composition:—

Silica	38	Ferric oxide	15
Alumina	22	Lime	23
Water	2		

Axinite.

Although almost a curiosity among gem-stones, yet fine crystals of axinite have been cut for ornamental use. It belongs to the triclinic system. The hardness of

axinite approaches that of rock crystal, but the brittleness of this substance almost precludes its being cut. It looks well *en cabochon*, and incurs in that form less liability to fracture. The specific gravity of transparent flawless axinite is 3·29; its colour ranges between a pale puce, a plum, and clove brown; it is generally strongly pleochroic, showing a white or straw yellow, an olive and a violet or purple image in different directions. The best specimens are found at St. Christophe in Oisans, Isère. The presence of boron in axinite is remarkable: tourmaline is the only other gem-stone in which the element occurs. The percentage composition of axinite approaches:—

Silica	43	Manganous oxide	3
Boron trioxide	5	Potash	1
Alumina	16	Lime	20
Ferric oxide	3	Magnesia	1
Ferrous oxide	7	Water	1

Sphene.

This mineral, when it occurs in sufficiently large crystals and is perfectly transparent, is occasionally cut as a gem-stone. Some beautiful specimens, chiefly of a honey-yellow or greenish-yellow colour, have been obtained from various localities in Tyrol, the United States, and Canada. Sphene or titanite is calcium silico-titanate and is remarkable, not only for its dichroism, but also for its strong dispersive power; a brilliant-cut stone is full of "fire." The specific gravity of sphene is about 3·5, but its hardness is low, just under 5·5. Sphene contains in 100 parts about:

Silica	31	Lime	27
Titanium oxide	41	Ferrous oxide	1

Sphene is now represented in the Museum Collection,
See Appendix facing page 158.

Benitoite.

Another compound containing titanium has been cut as a precious stone. This is benitoite, a newly-discovered mineral from San Benito Co., California. It is sometimes without colour, but generally possesses a lavender hue resembling iolite, when it shows strong dichroism. In composition it may be regarded as a barium silico-titanate. Its refraction is strong, and its density considerable—just over 3·64. In hardness it is distinctly superior to sphene, but it is scratched by rock crystal.

Cassiterite, Rutile, and Anatase.

These are binoxides, cassiterite or tinstone being that of tin, the two others being distinct forms of titanium binoxide. Cassiterite, when perfectly transparent and pale in colour, may be cut into a lustrous gem-stone. Its specific gravity is nearly 7, and its hardness about 6½. Rutile, when of a transparent red colour, yields a cut stone of very high refractive index, and presents a lustre almost metallic on the polished surfaces. But rutile is, perhaps, best known in the form of acicular crystals, red or reddish-brown in hue, which, when penetrating rock crystals, constitute the *Veneris crinis* of Pliny. Of anatase we need only say that some of the indigo-blue transparent and splendent crystals from Brazil have been mounted, either in their natural forms or step-cut, in jewellery. They have the form of beautiful low octahedra belonging to the tetragonal system: their specific gravity is about 4·86.

DIOPSIDE.

This mineral has been occasionally cut as a gem-stone ; it presents a close resemblance to dull green tourmaline or epidote. Its hardness, however, does not exceed 6. The specific gravity of a fine cut diopside was 3·306. Its colour is due to ferrous oxide. It contains about—

Silica	54	Magnesia	18
Lime	24	Ferrous oxide	4

APOPHYLLITE.

Apophyllite can hardly be regarded as a gem-stone, its softness causing its rapid abrasion. The hardness of apophyllite does not exceed 5 ; its specific gravity is 2·335 ; its colour varies from nearly transparent white to grey, yellowish, greenish, and flesh red. This mineral crystallizes in the tetragonal system, the forms assumed being usually an octahedron, with the solid angles truncated ; the basal planes have a decided pearly lustre, the other faces are merely vitreous.

Apophyllite is found in amygdaloid and related rocks, also in mineral veins, as at the silver mines of Andreasberg in the Harz. Greenland, Iceland, the Faröe Islands, also Poonah and Ahmednuggar in India, yield fine crystals. It also occurs in many Swedish, Tyrolese, and Transylvanian localities.

Apophyllite is nearly related to the zeolites, and is a hydrated silicate of lime and potash, with a little fluorine. Its percentage composition is represented by the following numbers :—

Silica	52	Potash	5·0
Lime	25	Water	16·5
Fluorine	1		

Apophyllite is represented in the Townshend Collection by one crystal:

Apophyllite. Translucent, white, natural crystal, prismatic octahedron with basal planes; $\frac{5}{12}$ in. diam.; claw mount. 1296—'69.

ANDALUSITE.

It is seldom that the mineral andalusite occurs in a perfectly transparent condition fit for cutting as a gem. Its colour is then of a somewhat reddish hue or pale amber brown, or light bottle green. But its beauty and interest mainly depend upon its conspicuous dichroism. Cut specimens often appear of a greenish hue, except in some of the end facets, where a fine brownish red occurs.* There thus arises a marked resemblance to alexandrite, which, however, is not only a much more valuable stone, but is also heavier and harder. It may also be confused with certain tourmalines of similar hue, but its specific gravity is rather greater, while the pyro-electric character of tourmaline affords a means of distinguishing the two stones. There is a fine oval faceted specimen in the Gallery of the École des Mines in Paris.

Andalusite, which crystallizes in the rhombic system, occurs in prismatically developed forms of which the section is nearly square. Its hardness is at least $7\frac{1}{4}$ and its specific gravity close to 3·18. Transparent specimens occur in some abundance in the Minas Novas district of Brazil, but are also found in certain gem gravels of Ceylon, where the stone is mistaken for tourmaline. A step-cut shape with few and rather large facets generally suits andalusite.

* Frontispiece, Fig. 7.

The composition of andalusite is identical with that of kyanite, a triclinic mineral of a beautiful blue colour. It contains in 100 parts about :—

Alumina .. 62·8 Silica .. 37·0 Iron oxides .. 0·2

Andalusite is now represented in the Museum Collection.
See Appendix facing page 158.

Jade and Jadeite.

Under the name of jade (a falsely coined word derived through the French from the Spanish *piedra de hyada*) two distinct minerals are included. One of these, the commoner of the two, is also lighter and softer, and belongs to the species known as hornblende or amphibole; to it the name jade (or perhaps preferably nephrite) should be confined. It is a compact mineral consisting of irregularly interwoven acicular crystals of the sub-species actinolite. Its surface when polished acquires a soft greasy lustre; its substance, though remarkably tough, is easily scratched by rock crystal. Jade presents a variety of hues ranging from a rather creamy white through a number of tones of greyish and leaf-green to a deep or blackish green. An ochre-tinted jade also occurs, as well as examples in which browns and reddish browns, due to ferric oxide and ferric hydrate, make their appearance. The dark grey and blackish varieties contain inclusions of chrome iron. But whatever the colour of jade, it is always translucent, never transparent on the one hand nor opaque on the other. Of its many varieties perhaps the green of New Zealand and the white or greenish white sort from Eastern Turkestan are the most familiar to Europeans.

Jadeite is as tough as jade, and takes the same polish, but it is much rarer as well as harder and heavier. Moreover

it often presents, even to the unaided eye, an obvious crystalline texture, while the most esteemed variety is of a brighter and more emerald-like green than any jade. Some specimens show in parts a delicate lilac tinge. It is from Burma that the jadeite worked by Chinese lapidaries comes. It is never found in such large masses as those in which jade occurs, but is sometimes of sufficient dimensions to be fashioned into fair-sized bowls six inches or more in diameter. Jadeite, especially the emerald green variety, is, however, more generally employed for smaller objects, such as snuff-bottles, bracelets, carved plaques, inlays, rings, and beads. It belongs to the pyroxene group of minerals and is therefore nearly related to diopside and to spodumene.

The chief distinctive characters of jade and jadeite may be summarised in the following tabular statement, where the chemical composition of typical specimens of each species is presented in percentages:—

	Jade.	Jadeite.
Silica	58·0	58·0
Alumina	1·3	**24·5**
Ferrous oxide	2·0	1·0
Magnesia	**24·2**	1·5
Lime	**13·2**	2·3
Soda	1·3	**12·7**
Hardness	6°	7°
Specific gravity	2·98	3·33

For further details concerning the archæology and artistic use of jade and jadeite reference should be made to Dr. Bushell's Handbook of Chinese Art, vol. i, pp. 126–142. In Mr. Spencer's translation of Dr. Max Bauer's "Precious Stones," pp. 458–470, will be found a full account of the occurrence, composition and properties of these two minerals.

PYRITES.

There are two minerals having the same two elements in the same proportions as constituents, but differing in physical and chemical characters. These two minerals are pyrite or iron pyrites, and marcasite. Both contain iron and sulphur, 46·7 per cent. of iron, and 53·3 per cent. sulphur, corresponding to 1 atom of iron and 2 atoms of sulphur. The properties of the two minerals may be compared thus :—

	Pyrite.	Marcasite.
Hardness	6·5	6·0
Specific gravity	5·2	4·8
Crystalline form	Isometric.	Orthorhombic.
Colour	Brass yellow.	Pale or grey yellow.

Pyrites is the more abundant form of this compound of iron and sulphur. It was largely used in jewellery in the eighteenth century, and is often incorrectly spoken of as marcasite. It takes a fine polish, and presents the appearance of a metal. It is of no value whatever from a commercial point of view, although a good deal of time and trouble were frequently spent in cutting specimens of it into faceted forms, such as single "roses." Pyrites was used by the ancient Mexicans, along with turquoise and obsidian, for the mosaic inlays and incrustations. In the Christy collection of the British Museum is a Mexican mask, in which the eyes are represented by hemispheres of pyrites.

The cut specimen of Pyrites in the Townshend Collection has lost its lustre through corrosion :

Pyrites. Brass yellow, rose-cut ; $\frac{1}{2}$ in. by $\frac{1}{3}$ in. ; light coronet mount. 1335—'69.

Hæmatite.

Black hæmatite is an oxide of iron occurring under several common names, as specular iron ore, iron glance, and micacious iron ore. Its powder is red, though a perfectly polished artificial or natural surface presents a metallic black lustre with slight iridescence. It has been employed, cut *en cabochon*, to simulate black pearls. The hardness of the densest hæmatite is 6·5, and its specific gravity 5·3. It contains in 100 parts:

Iron	70	Oxygen	30

Amber

is hardly to be reckoned amongst precious materials of mineral origin, for not only is it comparatively abundant, but it is an almost unchanged vegetable product, a fossilized resin of certain conifers of tertiary age. Its specific gravity is about 1·08, and its hardness 2·5. When traces of moisture and ash are deducted, it contains in 100 parts about :

Carbon	78·5	Oxygen	10·5
Hydrogen	10·5	Sulphur	0·5

Amber, whether from the Baltic shores, Sicily, or the coasts of Norfolk and Suffolk, is essentially the same substance, although the Sicilian amber sometimes exhibits a deeper and redder or browner hue, and often shows a bluish or greenish fluorescence. The amber from Upper Burma may perhaps be a different resin, but it presents, in many specimens at least, very much of the same range of yellow hues as Baltic amber. But *burmite*, as it has been called, occurs sometimes having a purplish brown colour : in the Indian Section of the Victoria and Albert Museum there is a specimen of this kind nearly a foot in

length, from King Theebaw's Palace at Mandalay. It is carved into the form of a duck. Beads and other objects of amber are frequently found in early burial places in Europe. Usually the surfaces have become somewhat darker in colour, less translucent, and somewhat friable: in some instances, however, the material has resisted oxidation in a remarkable manner, witness the amber objects from some of the primitive graves at Abydos and the beautiful amber cup in the Brighton Museum.

Although imitations of amber in yellow glass may be easily detected by means of their coldness to the touch and by their greater density, it is more difficult to distinguish copal resin from amber; still the odour of the latter when rubbed vigorously affords one means of identification.

JET.

Jet can hardly be regarded in any sense as a precious stone, although it has been used from early times for beads, pins, armlets, and other objects of personal adornment. Many examples in perfect preservation have been found in Celtic and Romano-British graves. Jet is a dense, homogeneous, perfectly black variety of coal, having a hardness approaching 4° and a smooth conchoidal fracture. It is still worked to some extent at Whitby on the Yorkshire coast.

MALACHITE.

Malachite is never used in the higher class of jewellery; its softness, opacity, and crude hue are not in its favour. In Russia veneers of it are employed with very bad effect in the decoration of vases, furniture, and even doors. Its hardness is 4, and its specific gravity 4.

The concentric veinings and markings of malachite showing its deposition from water, vary in depth of tint and often exhibit a satiny texture.

Malachite belongs to the hydrated carbonates, and is represented by the chemical formula $Cu\,CO_3$, $Cu\,H_2O_2$; it is therefore near chessylite or azurite $2\,Cu\,CO_3$, $Cu\,H_2O_2$. Malachite contains, in percentages, about the following proportions of its three constituents:—

Copper oxide	72	Carbon dioxide	20
Water	8		

Malachite is represented in the Townshend Collection by one specimen:

Malachite. Opaque, bluish green; ½ in. diam.; convex top, coronet mount. 1334—'69.

Lumachella

is a precious marble. It consists of a brown limestone, in which occur numerous fossil shells, having brilliant fiery red, green, or yellow chatoyant reflections. It comes from Bleiberg in Carinthia, and from Astrakhan. It is an impure carbonate of lime.

Lumachella, or Fire Marble, is represented in the Townshend Collection by one specimen:

Lumachella. Polished, nearly flat oval; 1 in. by ¾ in.; coronet mount. 1237—'69.

Pearl.

Although nearly all those bivalves which have nacreous shells do occasionally produce pearls, there are two molluscs which must be regarded as pearl-bearers *par excellence.* These are the pearl-oyster and the pearl-mussel.

The best known pearl-oyster is the small species *Margaritifera vulgaris*, which yields the famous pearls of Ceylon. A larger species, *Meleagrina margaritifera*, occurs in the Persian Gulf, Madagascar, the west coast of Central America, California, and West Australia. The shells of these oysters are particularly valued on account of the mother-of-pearl which they yield. From the pearl-mussel, *Margaritana margaritifera*, which belongs to the family of the Unionidæ, the pearls of Scotland, North Wales, and the English Lake District are derived. These British pearls possess generally in a very small degree that "orient" or iridescent sheen which constitutes the peculiar charm of this gem; but some specimens of great beauty have been found from time to time. A pearl of particular purity from the river Conway, North Wales, was presented to the Queen of Charles II. by Sir R. Wynne, and is now in the Royal Crown. The author of this handbook has seen a few fine pearls taken from mussels in the river Irt in Cumberland. The somewhat clouded "orient" of the majority of British pearls accords with dead or matt gold and with many deep-coloured stones.

Pearls are sometimes found having a decided tinge of colour; rose-coloured, salmon-pink, pale blue, russet-brown, olive-brown, and black pearls are highly esteemed; dull and muddy hues are less appreciated, and so also are extremely small pearls, which, indeed, are by far the most abundant. Pearls may be dyed easily, and are liable to become discoloured by wear. Pink coral, cut into suitable forms, is often made to simulate pink pearls, but its texture is entirely different, and may readily be recognised with the aid of a pocket lens. Black hæmatite, one of

the chief ores of iron, makes, when not too highly polished, a passable imitation of a black pearl; but nothing is easier than to detect the substitution, for hæmatite is more than twice as heavy as the pearl.

The substance of the pearl is identical, or practically identical, with the nacreous material, the mother-of-pearl, which lines the interior of the shell. It consists of that form of calcium carbonate which is known as aragonite and is rather harder and heavier than calcite, the other and commoner form. The aragonite in a perfect pearl is arranged in regular concentric layers, like the coats of an onion, and is always associated with a small quantity of an organic substance allied to horn. In some pearls the horn-like body occurs in larger proportion, and may even constitute one or more distinct layers. And occasionally layers of the commoner form of calcium carbonate, that is, calcite, occur in pearls—such layers are quite dull. The specific gravity of pearls is about 2·67, their hardness nearly 4°. The delicate colouration of the finest pearls is not due to any kind of pigment, but to the peculiar "intimate" structure of the nacre producing colour-effects through interference. Occasionally a dull pearl, when carefully peeled by mechanical means, will reveal a fine orient beneath, and be consequently greatly improved in appearance by the treatment.

Pearls are secreted by the mantle of the mollusc, and in the same way as that by which the shell itself is formed. Definite areas of the mantle have definite functions, secreting, as the case may be, either aragonite, or calcite or the horn-like substance already named. According to the position of the pearl in the region of the mantle—a position which is subject to change—so will be the nature

of its successive additional coats. But it will be asked "How does the pearl, the detached pearl for example, first come into being?" Its occurrence, if not rare, is at least abnormal, and is the outcome of irritation to the mantle caused by the intrusion of some foreign body. This foreign body is usually a minute parasitic animal (a Cestode larva), but may be a grain of sand, or some other solid. The irritation stimulates the secretion of nacre, and the intruder is sooner or later covered with layer after layer. The Chinese take advantage of this response to the irritation caused by the introduction of a foreign body in the case of a fresh-water mussel (*Dipsas plicata*). They keep the mussels in a tank and insert between the shell and the animal rounded bits of mother-of-pearl or little metal images of Buddha. In either case the inserted object becomes slowly coated with nacre and looks like a pearl: the little figures of Buddha generally become cemented to the shell; a specimen may be seen in the shell gallery of the British (Natural History) Museum.

The value of pearls is increased greatly when a considerable number of well-matched specimens are got together. But the market value of pearls depends upon so many factors, that even for a single pearl of what may be called standard quality, and perfectly spherical form, the price can hardly be stated with exactness. Such a pearl is perhaps worth £10 if it weigh 1 carat, four times as much if it weigh 2 carats, and eight times as much if it weigh 4 carats. Button-pearls, which have one side convex and the other flat, are less valuable than round pearls, but pear-shaped pearls often fetch more. The large, irregular, and grotesque pearls called *baroque* acquire value when set into curious figures—busts, dragons, griffins,

fruits, etc.—by the aid of gold and enamel mountings. Fantastic arrangements of this kind exercised the skill of many sixteenth and seventeenth century jewellers, but the artistic merit of these productions cannot be appraised very highly; the chief excuse for their existence must be sought in the difficulty of making any other use of the misshapen pearls in question. The Green Vaults of Dresden are rich in specimens of this sort. It should be mentioned that the majority of pearls used in ordinary jewellery are half-pearls, that is, pearls sawn in half. Seed pearls, the small pearls attached as pendants to jewels, the pearls sewn on garments, and necklace pearls, are perforated by careful drilling.

Pearls have been used in almost all parts of the world, and from very early times, for jewellery and personal adornment. The pearls set in antique Roman ornaments have rarely survived intact to the present day. Sometimes the place of a pearl in the setting is represented by a small brownish residue; sometimes the reduced form of the pearl is still to be seen, deprived of much of its lustre by the long-continued action of water charged with carbonic and vegetable solvent acids from the earth.

There are four Pearls in the Townshend Collection:

Pearl. Whole, white, secured by a pin passing through a claw on each side; on each shoulder of the ring-mount are 2 pearl-shaped brilliants, with 3 smaller brilliants, there are 4 other small brilliants, one at each corner of the setting. 1337—'69.

Pearl. White, whole, short ovate; diam. $\frac{1}{4}$ in.; mount with 4 claws. 1340—'69.

Pearl. Black, whole, round; diam. $\frac{1}{5}$ in.; plain mount with 4 claws. 1338—'69.

Pearl. Cherry pink, whole, round; diam. $\frac{1}{8}$ in.; claw mount. (Hope, catalogue, p. 10, No. 88.) 1339—'69.

CORAL.

The use of coral in jewellery justifies us in adding a few words here concerning this product of animal origin. All the white, pink, and red coral used for objects of personal adornment is derived from a single species, *Corallium nobile*, belonging to the sub-class Alcyonaria, class Anthozoa, and sub-kingdom Cœlenterata; the rare black coral, which is entirely horny and has but a trace of earthy matter in its composition, belongs to the other sub-class of Anthozoa, namely Zoantharia. The solid compact part of the coral animal, or polypdom, in the case of *Corallium nobile*, is mainly calcium carbonate (carbonate of lime), with small quantities of magnesium carbonate, iron oxide, and organic matter; the exact nature of the red colouring matter remains unknown.

Coral is mainly obtained from the Mediterranean, the coasts of Provence, Majorca, Minorca, and North Africa being the best localities. The coral grows on rocks at depths varying from 30 to 130 fathoms, but a depth of 80 fathoms is considered most favourable.

The price of coral varies much—from five shillings to £120 the ounce; the pale rose-pink variety is the most esteemed.

A good series of specimens of coral was bequeathed to the Museum in 1870 by Mr. Alfred Davis; it is now in the Branch Museum at Bethnal Green.

Several beautiful minerals and other natural products not entitled to rank as precious stones have been described in the preceding pages. A limit had to be set to the expansion of this handbook, or space might have been found for notices of—apatite, a calcium fluo- or chloro-phosphate with a hardness of 5 and a density of 3·2, sometimes occurring in perfectly transparent crystals of leaf-green or sky-blue hues; fluor-spar, a still softer mineral less suitable for use as a gem; and idocrase or vesuvianite, a calcium aluminium silicate much resembling epidote (page 142), and having a hardness of 6½ and a density of 3·4.

There are two specimens not mentioned in the preceding pages. One of these has been enumerated with the peridots, but it is apparently a tourmaline; the other stone, which possesses little interest or beauty, is probably obsidian.

Tourmaline? Dull green, *en cabochon*, oval; $\frac{1}{2}$ in by $\frac{1}{3}$ in.; plain mount. 1299—'69.

Obsidian? Dull green, step-cut; $\frac{1}{2}$ in. by $\frac{5}{12}$ in.; wire coronet mount. 1295—'69.

APPENDIX.

List of the Precious Stones Presented by Sir Arthur Church, K.C.V.O., F.R.S.

(*See Note on page* ii.)

Corundum. White Sapphire, brilliant-cut, oval, $\frac{1}{2}$ in. by $\frac{7}{16}$ in.; coronet mount. M. 2—1913.

Tourmaline. Salmon-pink, brilliant-cut, round, $\frac{7}{16}$ in. diam.; coronet mount. M. 3—1913.

Tourmaline. Straw-yellow, brilliant-cut above, step-cut below, oblong with rounded corners, $\frac{7}{16}$ in. by $\frac{5}{16}$ in.; coronet mount. M. 4—1913.

Garnet. Green, Demantoid or Andradite, the Olivine of jewellers, step-cut, nearly $\frac{1}{4}$ in. square; coronet mount. M. 5—1913.

Spodumene. Pale straw-yellow, brilliant-cut, $\frac{5}{16}$ in. by $\frac{9}{32}$ in.; coronet mount. M. 6—1913.

Zircon. Full leaf-green, brilliant-cut, oval, $\frac{15}{32}$ in. by $\frac{11}{32}$ in.; coronet mount. M. 7—1913.

Opal. Fire-opal of Mexico, faceted, cushion shape, $\frac{7}{16}$ in. by $\frac{3}{8}$ in.; coronet mount. M. 8—1913.

Andalusite. Greenish-grey, brilliant-cut above, step-cut below, $\frac{1}{4}$ in. by $\frac{7}{32}$ in.; coronet mount. M. 9—1913.

Moonstone. White chatoyant, en cabochon, oval, $\frac{3}{4}$ in. by $\frac{19}{32}$ in.; coronet mount. M. 10—1913.

Sphene. Honey-yellow, brilliant-cut, round, $\frac{13}{32}$ in. diam.; coronet mount. M. 11—1913

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